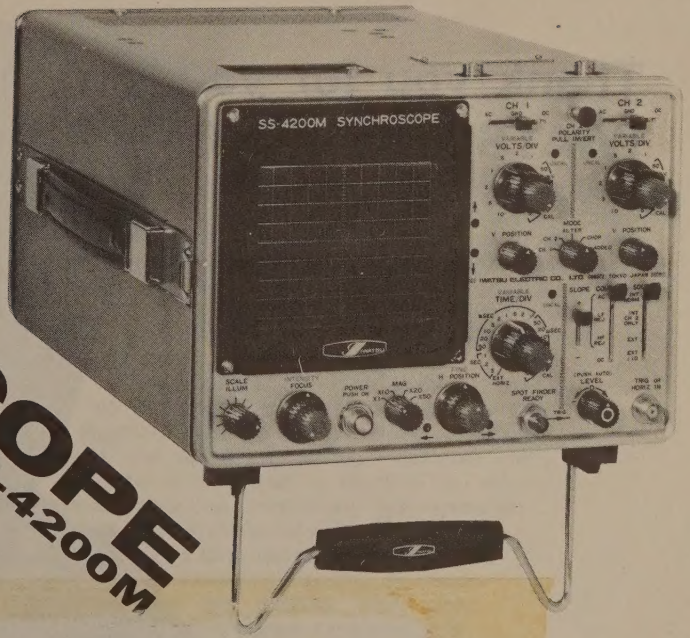
Electronic Services - Los Angeles
M13138X

SYNCHROSCOPE
SS-4200M
INSTRUCTION MANUAL

IWATSU

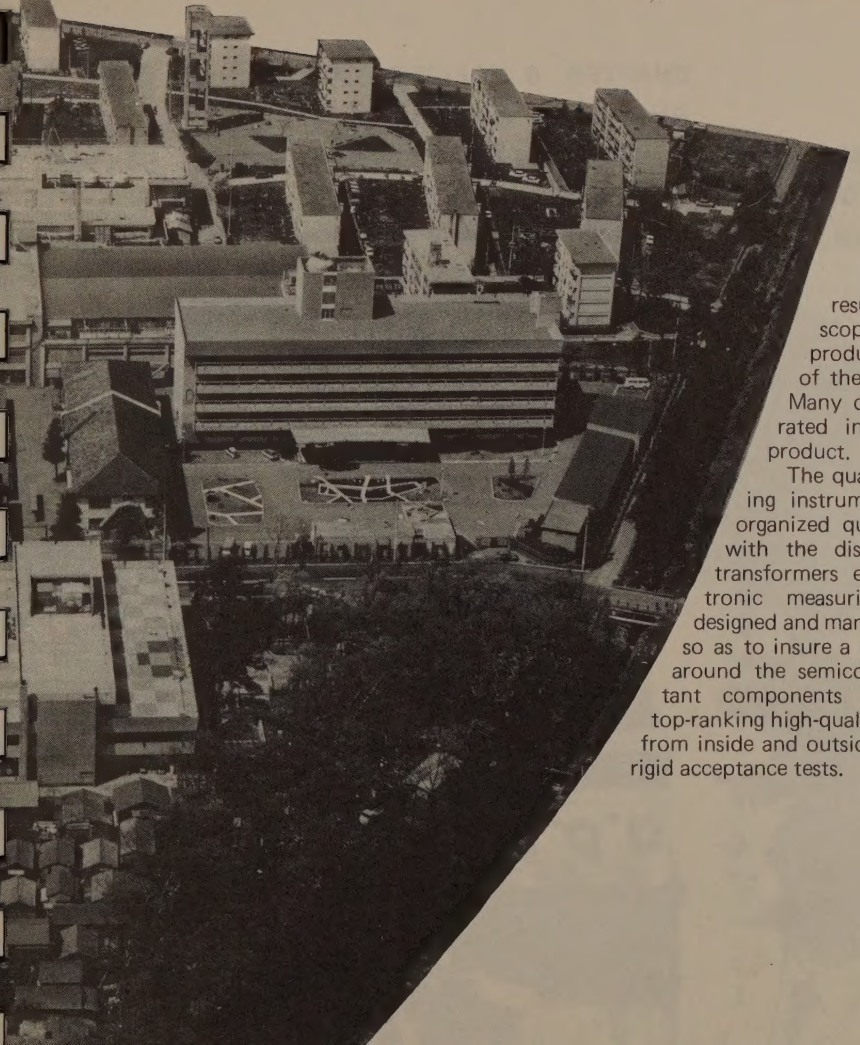
SYNCHROSCOPE

SS-4200M



1361010～ July 1970

Thank you for your purchasing an IWATSU SS-4200M Synchroscope.



The SS-4200M portable synchroscope is a result of IWATSU's most advanced synchroscope design techniques and many years of production experiences. IWATSU has been one of the pioneers of the synchroscope industry. Many design improvements have been incorporated in this highly reliable, portable type product.

The quality of IWATSU's electronic measuring instrument is assured by means of well-organized quality control systems which start with the disign engineering. Switches and transformers employed in the IWATSU electronic measuring instrument are specially designed and manufactured within the company so as to insure a long operating life. Centered around the semiconductor devices, all important components are selected from only top-ranking high-quality products supplied both from inside and outside of the company under rigid acceptance tests.

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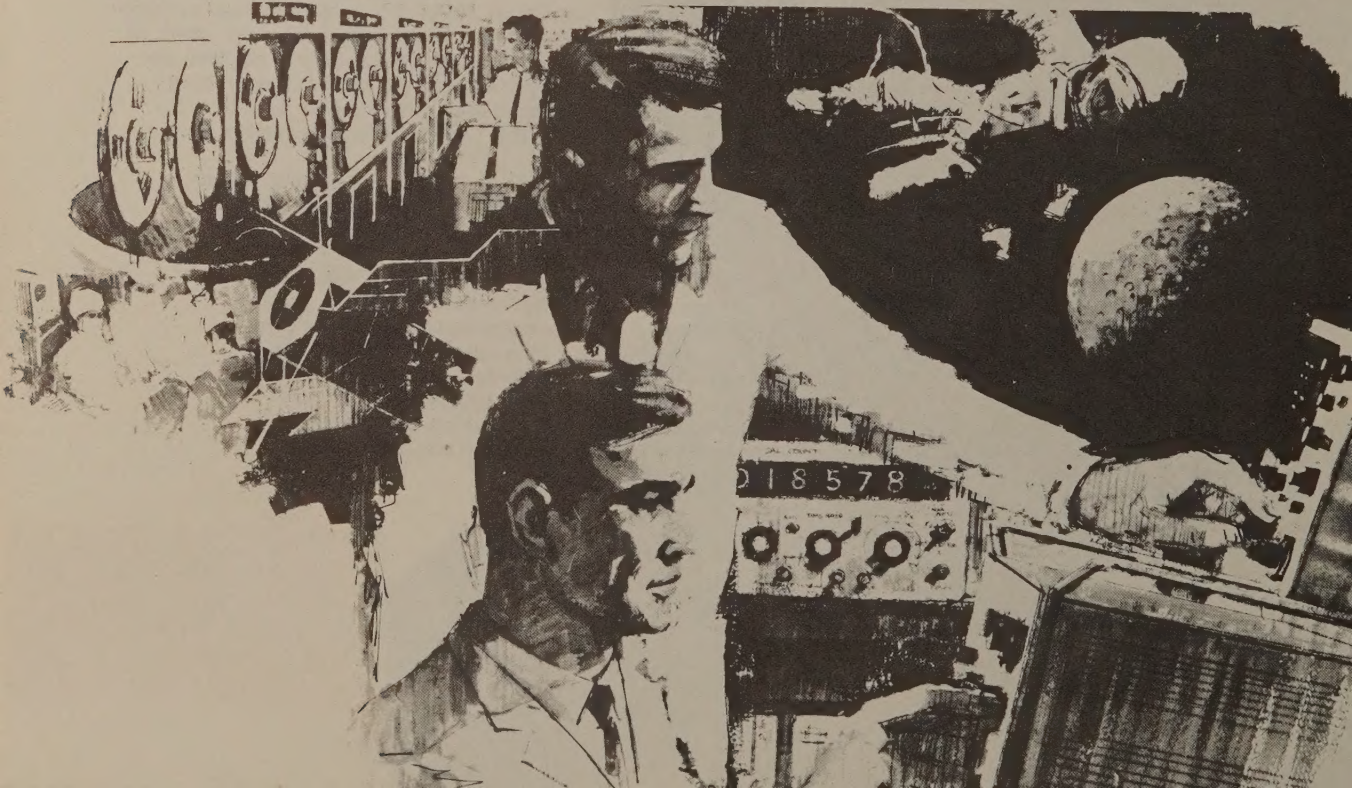


OUTLINE

SS-4200M is a miniature, portable synchroscope providing a variety of vertical and horizontal functions required of a synchroscope operating in the DC to 15MHz frequency band. The vertical deflection system provides an operating frequency range of DC to 15MHz on the electronically-switched dual trace operation basis with a high sensitivity of 5 mv/div for each channel.

The use of FET's (field effect transistors) in the input citcuit provides highly stable operation. Warmup time is only 15 seconds for proper operation. The horizontal deflection system provides a perfect trigger function for input signals from DC to 15 MHz.

A single sweep mode of operation is also possible. Error free observations over a wide range of signals are assured because of the internal graticule, 4 inch rectangular CRT which provides an effective display area of 8 vertical and 10 horizontal divisions (1 div = 8 mm).

COMPONENTS

The instrument consists of the main unit and below listed accessories.

MAIN ASSEMBLY
ACCESSORIES

BNC type lead (Black)	1
BNC type lead (Red)	1
BNC type lead C (Black)	1
Probe (Type 1017B1·B2)	2
Insulation adapter (C)	2
BNC L type adapter	2
Hexagonal spanner (4 mm)	1
Hexagonal spanner (3 mm)	1
Flat-blade screwdriver	1
Dustproof cover	1
Accessories bag	1
Instruction manual	1
Test data	1

CHAPTER 1 CHARACTERISTICS

In order to provide correct measurements with the synchroscope, it is necessary to understand the performance and accuracy of the instrument, which will be discussed in this CHAPTER.

For further details of operational controls and connectors, refer to Chapter 2 "Description of Operational Controls."

VERTICAL DEFLECTION SYSTEM

This system employs a dual trace facility with electronic switching for its preamplifier stage.

Some of the following characteristics and accuracies are commonly applied to both CH 1 and CH 2.

DEFLECTION SENSITIVITY

The vertical system provides calibrated deflection factors in 11 ranges from 5 mv/div to 10 v/div. The maximum calibrated vertical sensitivity is, therefore, 5 mv/div. In addition, the vertical sensitivity can be continuously attenuated, by turning the VARIABLE control, from 1/2.5 times (or more) as high as the calibrated value in each range. Thus attenuation of up to 12.5 v/cm (or more) can be provided.

FREQUENCY BANDWIDTH

The following frequency responses are provided, depending upon the position of the AC-GND-DC switch.

For DC coupling: Within –3dB from DC to 15 MHz

For AC coupling: Within –3dB from 3 Hz to 15 MHz

RISE TIME

24 nsec (nsec = nano second = 10^{-9} second)

SQUARE WAVEFORM RESPONSE

The instrument provides the following response characteristics with regard to a square waveform with a rise time of 3 nsec.

Overshoot	3% or less
Undershoot	2% or less
Ringing	0.5% or less
Sag (at 250 kHz)	1% or less
Sag (at 60 Hz)	1% or less

SIGNAL DELAY TIME

Approx. 120 nsec

COUPLING

Three ranges are available, AC, DC and GND which is used to check ground potential. In AC position, the instrument has a frequency response of –3dB attenuation at approx. 3 Hz. In DC position, a direct coupling is made available.

INPUT IMPEDANCE

Direct coupling:	1 MΩ with 25 pF or lower capacitance in parallel
Probe coupling (10:1):	10 MΩ with 18 pF or lower capacitance in parallel

Table 1–1

Method of Coupling of Input Signal		Maximum Input Voltage
When connected directly to the INPUT connector	When the VOLTS/DIV switch is set to 5 mV range	500V (DC + AC peak)
	When the VOLTS/DIV switch is set to a position other than the 5 mV range	600 V p-p
When coupled through the attached probe		600 V p-p

MAXIMUM INPUT VOLTAGE

This voltage depends upon the method of coupling of the signal to be measured (hereafter referred to as "input signal.") as shown in Table 1-1.

MODE SELECTION

CH 1 only
CH 2 only
ALTER (Sweep alternately switched to CH 1 and CH 2)
CHOP (Sweep switched between CH 1 and CH 2 at switching frequency of approx. 100 kHz)
ADDED (CH 1 ± CH 2)

POLARITY SELECTION

Normal and inverted polarities are available in CH 2 only.

COMMON MODE REJECTION RATIO

When the instrument is used in the ADDED mode (CH 1 – CH 2), a differential signal is applied across CH 1 and CH 2 inputs. In this mode, a common mode rejection ratio of at least 20 : 1 (at an input signal frequency of 1 kHz) is provided.

LINEARITY

With an input signal of approximately 1 kHz applied, adjust the amplitude to 4 division and center it vertically on the graticule. Confirm that the amplitude remains within ±3% (±0.12 division) while moving the vertical position 2 division up and 2 division down.

DRIFT

Vertical drift, measured 30 seconds after applying power to the instrument, will be as follows.

0,3 division/hour when the VOLTS/DIV switch is set to the 5 mV range.

SELECTION OF INTERNAL TRIGGER

Then operating in the internal trigger mode, it is possible to select the type of internal trigger signal: that is, a trigger signal derived from a common output of the vertical deflection system (when the SOURCE switch is set to the INT MORM range) or an independent trigger signal derived from the input signal on CH 2 (When the SOURCE switch is set to the INT CH 2 ONLY). Stable triggering is possible by means of an internal trigger signal for dual trace operation when the SOURCE switch is set to the INT CH 2 ONLY.

HORIZONTAL DEFLECTION SYSTEM

SWEEP TIME (TIME/DIV)

The instrument provides 20 calibrated ranges for a sweep time from 0.2 μsec/div to 0.5 sec/div. In addition, the sweep time can be continuously varied by adjusting the VARIABLE control and can be slowed down to 1/2.5 times (or more).

Therefore, the minimum sweep time available is at least 1.5 sec/div.

When the VARIABLE control is turned to the extreme clockwise position (In condition of no lighting), accuracy of the sweep time in each range will be within ±3%.

LINEARITY OF SWEEP

Within ±3% in each of the TIME/DIV ranges.

MAGNIFICATION OF SWEEP

Four positions (X1, X10, X20, X50) are provided for horizontal trace expansion from the center of graticule. The sweep time accuracy and linearity at each sweep magnifier position are as indicated in Table 1–2 below.

Table 1–2

MAG Range	TIME/DIV	Performance and Accuracy
X10	.5 sec – .2 μsec	Within T.L. ±2%
X20	.5 sec – .1msec 50 μsec – .2 μsec	Within T.L. ±3% Within T.L. ±5%
X50	.5 sec – .1msec 50 μsec – .5 μsec	Within T.L. ±5% Within T.L. ±7%

Note: T and L in the above table signify the sweep time and linearity at the X1 position of the sweep magnifier.

SINGLE SWEEP RATE

A single sweep mode is also provided.

MAXIMUM SWEEP

A maximum sweep rate of 0.01 μsec/div is obtained by magnifying the maximum sweep time of 0.2 μsec/div by 20.

EXTERNAL SWEEP

Refer to Table 1–3

Table 1–3

Characteristic	Performance and Accuracy
Deflection Sensitivity	0.05 V/div within ±3% or less (EXT) 0.5 V/div within ±3% or less (EXT ÷ 10)
Frequency Bandwidth	Within –3dB from DC to 3 MHz
Frequency Bandwidth Available for Phase (Frequency Ratio) Measurement	DC to 50 kHz (Phase difference at 50 kHz is 3^{O} or less)
Input Inpedance	1MΩ shunt by 20pF

TRIGGERING

TYPES OF TRIGGER SIGNAL SOURCE

Four types are provided; internal (INT NORM, INT CH 2 ONLY) and external (EXT, EXT ÷ 10).

POLARITY

+ (An input signal is triggered from a positive change in the input signal).
– (An input signal is triggered from a negative change in the input signal).

TRIGGER SIGNAL INPUT COUPLING

This is available in four ranges, AC, LF REJ, HF REJ and DC. The frequency range in which triggering is possible for each range is specified in Table 1–4.

Table 1–4 Frequency Range and Level Available for Triggering

SOURCE	COUPLING	Frequency Range for Proper Triggering	Trigger Level	
			Internal	External
INT NORM or INT CH 2 ONLY	AC	50 Hz – 8 MHz	0.5 division or more	0.1 V or more
		8 – 15 MHz	1.0 division or more	0.2 V or more
	LF REJ	30 kHz – 8 MHz	0.5 division or more	0.1 V or more
		8 – 15 MHz	1.0 division or more	0.2 V or more
	HF REJ	50 Hz – 10 kHz	0.5 division or more	0.1 V or more
INT NORM	DC	DC – 8 MHz	0.5 division or more	0.1 V or more
		8 – 15 MHz	1.0 division or more	0.2 V or more
INT CH 2 ONLY	DC	30 Hz – 8 MHz	0.5 division or more	———
		8 – 15 MHz	1.0 division or more	———

Caution: (In the auto mode, triggering is inperable at frequencies of 50 Hz or lower even if COUPLING is set to DC.)

INPUT IMPEDANCE OF EXT TRIG IN CONNECTOR

1 MΩ with a parallel capacitance of 25 pF or lower

FREQUENCY RANGE AND LEVEL PROPER TRIGGER OPERATION

Refer to Table 1–4

SELECTION OF AUTO OR TRIGGERED

Either the auto or triggered mode can be selected by pushing or pulling the (PUSH AUTO) LEVEL switch. In the auto mode, input signals of 50 Hz or lower can not be triggered, and while the trigger is inoperable, the sweep is self-controlled. Whereas the triggered mode, the trigger will be operable from DC. While the trigger is inoperable, the scope remains in standby, indicated by a spot.

OUTPUT SIGNAL

GATE

A negative square wave approx. 1 Vp–p, synchronized with an output impedance approx. 1 kΩ (When the load impedance is 100 kΩ or higher).

CALIBRATION VOLTAGE

The calibration voltages specified in Table 1–5 are obtained from the CAL OUT terminal.

Table 1–5

Characteristic	Specification and Accuracy
Voltage	Square Waveform in 3 terminals (0.02V, 0.2V, 2V Accuracy; ±3% or less)
Frequency	1 kHz Accuracy; ±0.5% or less
Duty Ratio	49 : 51 or lower
Waveform Respons	Rise time; 0.2 μsec or less Fall time ; 0.4 μsec or less

CATHODE RAY TUBE

CATHODE RAY TUBE

Refer to Table 1–6 for specifications

ACCELERATING VOLTAGE

Approx. 6.5 kV

EXTERNAL INTENSITY MODULATION

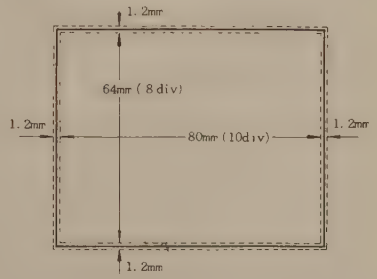
Intensity Modulatable minimum input volage is +2 Vp–p.

The input impedance of Z AXIS INPUT is approx. 470 Ω.

COINCIDENCE OF TRACE WITH GRATICULE

This can be accomplished by adjusting the TRACE POTATION.

Table 1–6

Item	Specification
Type No. –	H8503A–B31
Size	4 - inch Rectangular screen Internal graticule
Effective Area of Screen	8 division (vertical) x 10 division (horizontal)
Distortion	Bending of the trace, measured as shown below vertically and horizontally around the graticule where the worst condition is obtained shall be as follows: 

POWER SUPPLY

APPLICABLE VOLTAGE RANGE

This instrument can be used with the line (commercial source) voltage as in the table 1–7 by operating the 200V – 230V switch on the rear panel.

Table 1–7

200V – 230V switch	Usable line voltage range
Turned to 200V position	180V to 220V
Turned to 230V position	207V to 253V

LINE FREQUENCY

From 50 Hz to 400 Hz

POWER CONSUMPTION

Approx. 45W

AMBIENT CONDITIONS

OPERATING AMBIENT TEMPERATURE RANGE

This instrument will operate properly in an ambient temperature range from –10°C to +50°C.

HUMIDITY RANGE (RELATIVE HUMIDITY)

This instrument will operate properly at 40°C with a relative humidity of up to 85%.

VIBRATION

The instrument will withstand vibration with a constant peak-to-peak displacement of 1.5 mm at 1,000 cycles/min. when held on each of the three major axes for an hour.

SHOCKS

It will withstand three shocks in each direction along each major axis, applied by lifting the equipment 5 cm at a maximum tilt angle of 30 degrees, then dropping it onto a hard surface.

CONSTRUCTION

DIMENSION

Main assembly	Approx. 223 mmW x 160 mmH x 368 mmL
With panel cover and legs	Approx. 223 mmW x 180 mmH x 438 mmL

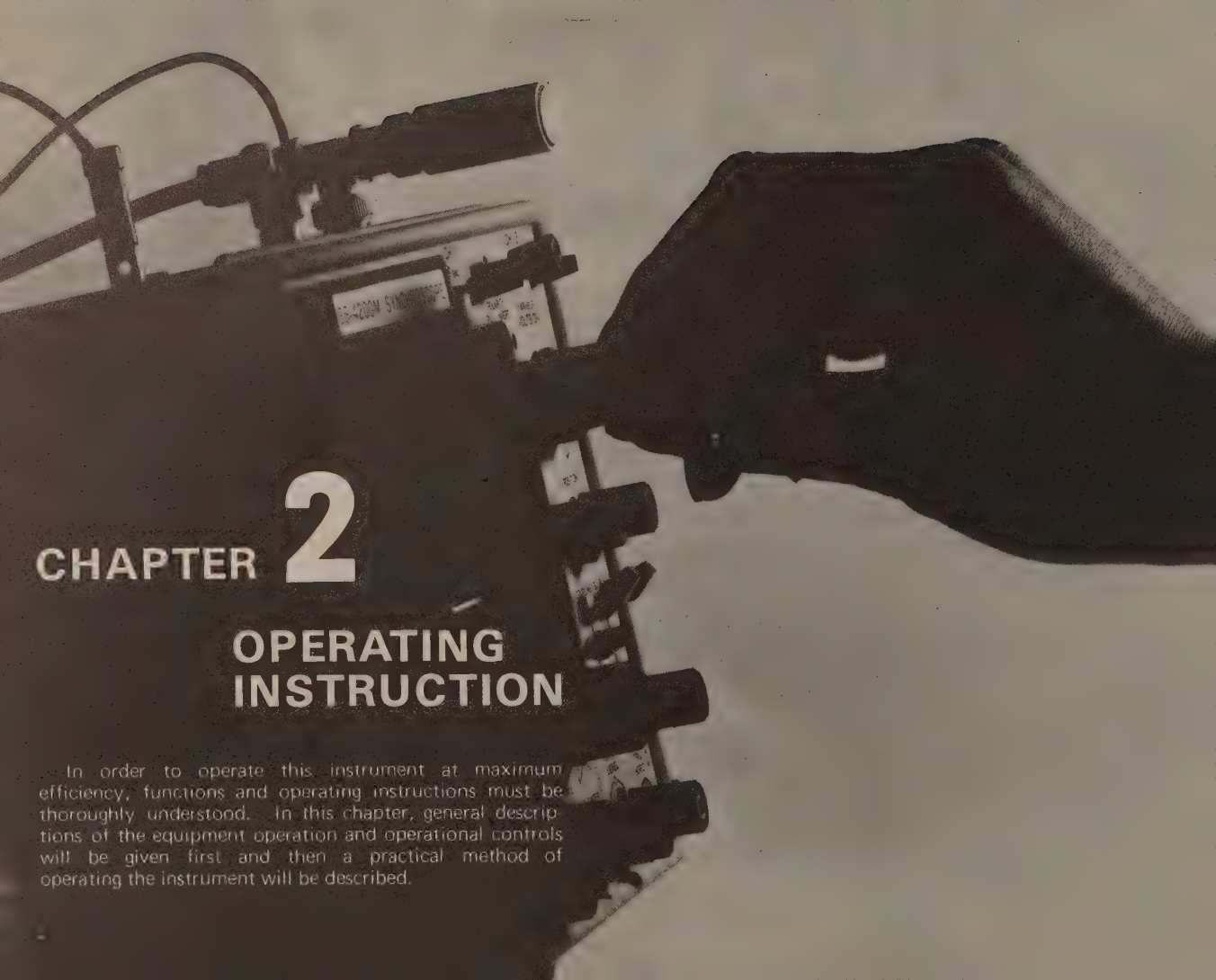
WEIGHT

Main assembly	Approx. 8 kg
With panel cover	Approx. 8.3 kg

COLOR

Front panel	White aluminum
Cabinet	Leather tone finished in Munsell notation 5GY 5/0.5

MEMO



CHAPTER 2

OPERATING INSTRUCTION

In order to operate this instrument at maximum efficiency, functions and operating instructions must be thoroughly understood. In this chapter, general descriptions of the equipment operation and operational controls will be given first and then a practical method of operating the instrument will be described.

GENERAL OPERATING INSTRUCTIONS

THREE HANDLING AND PANEL COVER

As seen from Fig. 2–1, there are three different ways of carrying this tiny synchroscope.

If the instrument is to be carried over a long distance, the method shown in Fig. 2–1 (a) should be followed. The method shown in Fig. 2–1 (b) is suitable for carrying it a medium distance and Fig. 2–1 (c) is for a short distance, that is, more relocation of the instrument in the same area. Exercise care in protecting the instrument from excessive shocks and vibrations when carrying.

The front cover, which is provided to protect the front panel, can be removed by releasing the two snap fasteners. Attach this cover whenever there is a danger of damaging the front panel during transportation or relocation.

Fig. 2–1

THREE OPERATING POSITIONS

This instrument can be operated in the three positions shown in Fig. 2–2, depending upon the situation. When it is used in the vertical position as shown in (c), be extremely careful so as not to tip it over by excessive pulling on the probe, etc. When the operating position is changed, the vertical position of the trace on the phosphor screen may shift slightly, however this is not abnormal. The trace will return to its original position almost immediately.

Fig. 2–2

(a) (b) (c)

REMOVAL OF POLARIZED FILTER

A polarized filter is used to absorb external light emitted onto the CRT screen, thus preventing refelections. It also provides a high contrast of the trace to facilitate the observation. When a display is to be photographed, remove the polarized filter to improve the definition as shown in Fig. 2–3.

Fig. 2–3

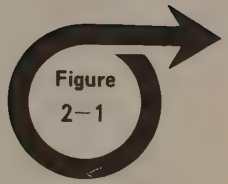
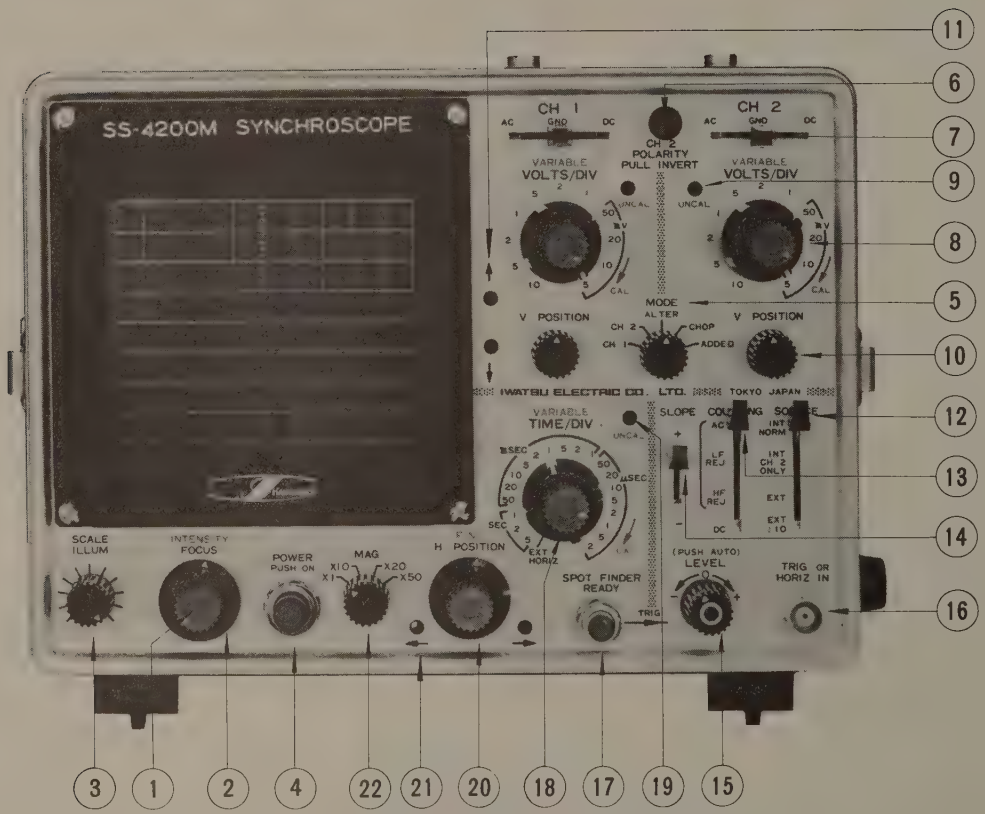


Figure
2—1


SS-4200M SYNCHROSCOPE
CH 1
CH 2
AC GND DC
CH 2 POLARITY PULL INVERT
VARIABLE VOLTS/DIV
UNCAL
CAL
MODE
ALTER
CH 2
CH 1
CHOP
ADDED
V POSITION
IWATSU ELECTRIC CO. LTD. TOKYO JAPAN
VARIABLE TIME/DIV
SLOPE
LF REJ
HF REJ
INT
INT NORM
INT CH 2 ONLY
EXT
EXT ÷10
SCALE ILLUM
INTENSITY FOCUS
POWER PUSH ON
MAG
X10
X1
X20
X50
H POSITION
SPOT FINDER READY
(PUSH AUTO) LEVEL
TRIG
TRIG OR HORIZ IN
11
6
7
9
8
5
10
12
13
14
16
3
1
2
4
22
21
20
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17
19
15

DESCRIPTION OF OPERATING CONTROLS

Functions of operational controls and connectors on the front and rear panels are described in the following paragraphs. In the case of dual knobs, slate grey knobs and red knobs will coincide with the indications in slate grey and red on the panel, respectively.

Refer to Fig. 2–4 (on next page)

FRONT PANEL

— CONTROLS FOR POWER SUPPLY AND CRT —

① INTENSITY

(Red knob) Controls brightness of spot or trace on CRT. Brightness will increase by turning this control clockwise and decrease by turning it counterclockwise. The trace will disappear when the control is set in the fully counterclockwise position.

② FOCUS

(Slate grey knob) Provides adjustment for optimum trace or spot definition in conjunction.

③ SCALE ILLUM

Permits brightness of the graticule markings to be varied.

④ POWER PUSH ON

When the power switch, which is used to turn the main power supply of the instrument on and off, is depressed, a pilot lamp located in the pushbutton will light. The power is turned off by depressing the switch again.

— CONTROLS FOR VERTICAL DEFLECTION SYSTEM —

Since the operational controls and connectors which are provided symmetrically for both CH 1 and CH 2 have the same functions, only those of CH 2 will be described.

⑤ MODE

Selects vertical mode of operation of the dual trace amplifier.

CH 1
Only CH 1 amplifier operates. The scope is used as a single trace synchroscope.

CH 2
Only CH 2 amplifier operates. The scope is used as a single trace synchroscope.

ALTER
Dual trace display of signals on both channels. CH 1 and CH 2 amplifier operations are switched at the end of each sweep. In this case, if the sweep time is too slow (approx. 2 msec/div or less), traces on CH 1 and CH 2 will alternatively appear on the CRT, therefore, simultaneous trace display can no longer be obtained. This means that simultaneous trace observation in the ALTER mode is suitable only for inputsignals of comparatively high frequencies. Simultaneous single sweep operation on the dual trace basis can not be performed in the ALTER mode.

CHOP

CH 1 and CH 2 amplifier operations are alternately switched at a repetition of approximately 200 kHz and two traces are displayed simultaneously. In this mode, traces on CH 1 and CH 2 are displayed as a series of spots, therefore, if the sweep time is set too short (approx. 50 μsec/div or faster), these dots may appear, thus making observation difficult. For this reason, dual trace display in the CHOP mode is only suitable for observation of comparatively low frequency input signals.

ADDED

CH 1 and CH 2 amplifiers operate at the same time to display the algebraic sum or difference signal of the two input signals on CH 1 and CH 2.

⑥ CH 2 POLARITY

Normal display in the PUSH position. Inverts the CH 2 display when set to PULL.

⑦ AC-GND-DC

Selects the method of coupling input signals to the SCOPE. When set to AC, input of the vertical amplifier is set for AC coupling, thus only the AC component is coupled to the vertical amplifier and DC is rejected even if the input signal is super-imposed on DC.
When set to DC, input signals including DC components can be observed.

When set to GND, the input signal is removed from the vertical amplifier and the input of the amplifier is grounded. In this manner, ground potential level (normally used as a reference in measurement) can be easily checked.

⑧ VOLTS/DIV

(Slate grey knob) Selects vertical deflection factor in 11 ranges from 5 mv/div to 10 v/div. Depending on the amplitude of the input signal, an optimum range, (for ease of observation) is selected.
When the VARIABLE control is turned fully clockwise (to the CAL position, where the UNCAL ⑨ lamp goes off), the indicated factor shows voltage per vertical deflection of 1 cm.

⑧ VARIABLE

(Red knob) Used as a fine control to continuously attenuate input signal. The attenuation ratio becomes a maximum of 1/2.5 (or more) when turned fully counterclockwise. Thus, it provides continuously variable uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV ⑧ switch. The VARIABLE control should be set to the CAL position for normal quantitative measurement of an input signal.

⑨ UNCAL

Light indicates that the VARIABLE ⑧ control is not in the CAL position, that is, the VOLTS/DIV ⑧ value obtained under this condition is not calibrated.

⑩ V POSITION

Controls vertical position of trace or spot. When the position of the display is higher than the desired position, turn this control counterclockwise. When it is lower, turn the control clockwise to return the trace to the center of the CRT screen.

When the CH 2 POLARITY ⑥ switch is placed in the INVERT position, the polarity of the display on CH 2 will be reversed.

⑪ ↕

In case the spot or trace moves up or down, this lamp goes on to indicate the direction of the shift. When the spot or trace moves off the screen, adjust the V POSITION ⑩ control to return it to the display area.

— TRIGGER SYSTEM —

⑫ SOURCE

Used to select trigger signal source or signal source for external sweep operation. (For further details, refer to page 2–14.)

INT NORM

With the SOURCE switch set in this position, the sweep is triggered by a signal internally derived from the CH 1 or CH 2 input signal.
This mode of operation should be applied particularly for single trace operation either CH 1 or CH 2. Positive triggering can not be provided when this mode is applied for the ALTER or CHOP operation.

INT CH 2 ONLY

In this position, the sweep is triggered from an internal trigger signal derived from input signal to the CH 2.
This mode is used preferably for a dual trace operation (ALTER or CHOP) for positive triggering.

EXT

In this position, a trigger signal is applied from an external source, that is, part of input signal or external trigger signal having a fixed time relationship with the input signal is applied to the TRIG OR HORIZ IN ⑯ connector. This position is also used for externally-controlled sweeping.

EXT ÷ 10

This position is also used for an external trigger mode, and an extraneous trigger signal is attenuated to 1/10 to provide a proper trigger level. Hence, it is used when the extraneous trigger signal level is so high that proper adjustment of the trigger level cannot be accomplished. In addition, this position can be conveniently used when an excessive input signal is applied in case of an external sweep.

⑬ COUPLING

Selects trigger signal coupling with the trigger circuit, depending on the type of the trigger signal, in order to insure correct trigger operation. In the external sweep mode, it also selects the input signal coupling. In external sweep operation, however, LF REJ and HF REJ can not be used. (For further details, refer to page 2–15.)

AC

In this position, the trigger mode provides AC coupling. Since the DC component of the trigger signal is rejected, triggering is not affected by the DC component.

LF REJ

This position provides coupling through a high pass filter which rejects low frequency noise or low frequency

(approximately 30 kHz or lower) trigger signals.

HF REJ

In this position, a low pass filter is used for coupling. In contrast with the LF REJ mode, high frequency noise or high frequency (approximately 10 kHz or higher) trigger signals are rejected.

DC

This position provides a DC-coupled mode of operation and a sweep can be triggered by a DC trigger signal. This position also provides the DC-coupled mode for an external sweep.

⑭SLOPE

Selects a positive or negative slope to start the sweep.

⑮(PUSH AUTO) LEVEL

Functions both as a potentiometer control and pushpull type switch. As a potentiometer, selects a trigger point on an input signal waveform at which sweep starts.
As a switch select trigger mode, that is, the mode is set to the triggered when the switch is in the pulled condition, thereby, signals from DC to AC can be triggered.
In the absence of a trigger signal or when the LEVEL ⑮, exceeds the trigger point, the sweep will stop and the scope will remain in standby with a spot. When pushed, the trigger mode will become auto mode, in which triggering can be done similarly to that of the triggered mode for trigger signals of 50 Hz or higher. If frequency of the trigger signal is 50 Hz or lower, or LEVEL ⑮ exceeds the trigger point, or in the absence of a trigger signal, the mode of sweep will become a free running sweep mode.

⑯TRIG OR HORIZ IN

Connector for an external trigger signal when using the external trigger mode. It is also used to connect an input signal for an external sweep. It's input impedance is 1 M Ω (with a parallel capacitance of 20pF or less).
The maximum input voltage is ±50V.
DO NOT APPLY EXCESSIVE INPUT VOLTAGES.

— CONTROLS FOR HORIZONTAL DEFLECTION SYSTEM —

⑰SPOT FINDER READY

A pushbutton switch used to ascertain the position of a missing spot. Since this instrument uses a deflection type unblanking system, the spot does not appear in the absence of sweep even if the brightness is increased (except for the external sweep).
In such a case, the spot will appear by pushing this push-button. A lamp incorporated in this pushbotton switch will light for the following indication purposes.

(1) To indicate a "ready" status of the instrument in the single-sweep mode.
(2) To indicate a non-triggered status (only when the trigger signal frequency is 100 Hz or higher).

⑱TIME/DIV

(Slate grey knob) Selects sweep time in 20 ranges, from 0.2 μsec/div to 0.5 sec/div, making possible the use of an optimum range for easy observation depending upon the frequency of the input signal.
The sweep time can be read directly from the knob indica-

tor when the VARIABLE ⑱, which will be described later, is turned fully clockwise (CAL position) at which time the UNCAL ⑲ light goes off.
When this switch is set in the EXT HORIZ position, the internal sweep generator stops operation and the horizontal deflection system will become capable of being controlled by an external sweep signal.

⑱ VARIABLE

(Red knob) A potentiometer used for the control of the sweep time. It is capable of providing a continuous adjustment of the sweep time of up to at least 1/2.5 times slower as much as each range of the TIME/DIV ⑱ values. When it is necessary to perform a quantative measurement, set the VARIABLE control to CAL.

⑲ UNCAL

Indicates uncalibrated operation. Goes on when the VARIABLE OR EXT HORIZ ATT ⑮ is set to a position other than CALIB to indicate that the TIME/CM ⑮ value is not calibrated.

⑳ H POSITION

(Slate grey knob) Controls horizontal position of a trace or spot. If the trace position is left of center, turn this knob clockwise. If the trace position is right of center, turn the knob counterclockwise to return the trace to the center of the CRT.

⑳ FINE

(Red knob) Used for fine adjustment of the H POSITION ⑳ (red knob) mentioned above. It is useful for observing a magnified display.

㉑ ⇄

Lights to indecate the direction when a spot or trace shifts horizontally. If the spot or trace has gone off the viewing area, use the H POSITION ⑳ to return it to the proper position.

㉒ MAG

Used to magnify the display 10, 20, and 50 times from the center of graticule. At the X50 position, however, the sweep time 0.2 μsec/div is noncalibrated.

TOP PANEL

INPUT CH 1 / CH 2

Used to connect input signal or probe. BNC type coaxial connector is used.

MODE NORMAL ⟷ SINGLE RESET

Selects mode of horizontal operation as follows depending on purpose or use.

NORMAL is range of conventional sweep mode. Sweep is carried out repetitiously with sawtooth wave signals generated inside of the instrument.

SINGLE is range used to provide a single sweep operation. Similar to NORMAL mode, sawtooth wave signals internally generated are used for sweeping, but differs from

the NORMAL mode in that sweep is provided only once.

In the SINGLE mode, push the RESET switch to make ready for a single sweep.

CAL OUT

A calibrating signal (1 kHz square wave) of the specified voltage can be fed from each of the jacks.

GND

Grounding terminal to provide a connection with ground lead of the input signal source.

ASTIG

A potentiometer used to adjust focus of a spot or trace when it cannot be perfectly adjusted by the FOCUS(2) control.

TRACE ROTATION

A potentiometer used to control the trace position so as to coincide with the graticule.

DC BAL CH 1 CH 2

If the input and following circuit of the vertical amplifier are not balanced, the vertical position of trace will change upon rotation of the VARIABLE(8)control. This control is adjusted for a minimum of change.

After once set for proper operation, further drift will rarely occur, however, the drift may again appear where fluctuation in ambient temperature is excessive.

REAR PANEL

POWER CORD

Main power is applied through this cord when connected to a convenient outlet on the main power line.

1A

A fuse holder containing a 0.5 A fuse. (Use 1 A fuse when the instrument operates on AC 100 V or 115 V line).

200V – 230V Switch

A switch used to select line voltage. Set it to 200V when the line voltage is 180 to 220V, and to 230V when the line voltage is 207 to 253.

Z AXIS INPUT GND

In case an external brilliance modulation is required, remove the shortcircuit bar and apply an external signal to the INPUT terminal. Connect ground side of the signal source to the GND terminal. Normally, the INPUT terminal is connected to the GND terminal through a shortcircuit bar.

GATE (–1V)

A square-wave signal of –1V synchronized with the sweep can be obtained. Output impedance is approximately 1 kΩ. (In case the load is 100 kΩ or higher.)

OPERATING PROCEDURES

In this paragraph, operating procedures for this instrument will be described. It is important to familiarize yourself with the operation of the instrument by actually using it with a variety of input signals. The instrument circuit will not be damaged even if the operational controls on the front panel are improperly set. Pay attention however, to the instructions given below as "Preliminary" each time you operate the instrument.

—PRELIMINARY—

CHECK THE LINE VOLTAGE !

First check the line voltage to be applied to this instrument. As it operates on the main supply voltage ranges specified in Table 2–1 (duplicate of the table in Chapter 1), change over the 200V – 230V switch correctly according to the line voltage. Application of line voltages other than those specified herein will cause trouble. If an appropriate commercial line voltage is not available, it must be obtained by proper step-up or step down transformers etc.

Table 2–1

200V – 230V switch	Usable line voltage range
Turned to 200V position	180V to 220V
Turned to 230V position	207V to 253V

AMBIENT TEMPERATURE !

For proper operation use the instrument at ambient temperatures from –15°C to +55°C.

DO NOT APPLY EXCESSIVE VOLTAGE !

The maximum input voltages applied to the CH 1 and CH 2 INPUT connectors and the probe are specified in Table 2–2 (duplicate of Chapter 1). Do not apply a voltage exceeding the specified value.

Table 2–2

Method of Coupling of Input Signal		Minimum Input Voltage
When connected directly to the INPUT connector	When the VOLTS/DIV switch is set to 5 mV range	500V (DC + AC peak)
	When the VOLTS/DIV switch is set to a position other than the 5 mV range	600 V p-p
When coupled through the attached probe		600 V p-p

EXCESSIVE INTENSITY !

Do not operate the oscilloscope with excessive intensity, or with the spot or trace moved off of the CRT screen for extended periods. This is to prevent burning of the fluorescent screen of the CRT and damage to circuit components.

DO NOT APPLY EXCESSIVE FORCE TO CONTROLS !

The instrument will not be damaged if the controls are improperly adjusted, but the controls and switches may be damaged if excessive force is applied.

DO NOT GROUND OUTPUT TERMINAL !

Do not connect the +GATE terminal to ground. The associated circuit will be damaged.

SPOT FINDER ⑰

This synchroscope employs a deflection type unblanking system in which the electron beam is deflected away from the CRT screen during fly-back time or a non-sweeping period.

The spot, therefore, will not appear even if the INTENSITY ① control is turned to the extreme clockwise position during a non-sweeping period of operation (except for the external sweep mode TIME/DIV ⑱ is set to EXT HORIZ). In this case, the spot will appear by pushing the SPOT FINDER ⑰ switch. This switch is conveniently used to find the spot (electron beam) especially during single sweep operation.

— OPERATION FROM SWITCH-ON TO SWEEP —

APPLICATION OF MAIN POWER TO OBTAIN A SPOT ON THE CRT

Insert the plug into a line receptacle, then set the following controls to the positions indicated.

INTENSITY ①	Fully clockwise
MODE ⑤	CH 1
CH 2 POLARITY ⑥	Push
AC-GND-DC ⑦ (CH 1)	GND
V POSITION ⑩ (CH 1)	Approximately midposition
SOURCE ⑫	INT NORM
MODEL (Top panel)	NORMAL
(PULL AUTO LEVEL) ⑮	PULL
H POSITION ⑳	Approximately midposition
FINE ⑳	Approximately midposition

Next, push the POWER ④ pushbutton and allow a warm-up time of approximately 15 seconds, then push the SPOT FINDER ⑰. A spot will appear on the left side of the CRT screen. Brightness is too high now, adjust the INTENSITY ① control counter-clockwise for proper brightness.

Then, set the TIME/DIV ⑱ to EXT HORIZ, and turn the H POSITION ⑳ control counterclockwise. A spot will now appear.

FOCUS

Move the spot to the center of the CRT screen by adjusting the V & H POSITION controls ⑩ and ⑳, then adjust the focus with the FOCUS ② controls.

SWEEP

Set the TIME/DIV ⑱ switch to the other range to except EXT HORIZ and push the (PUSH AUTO) LEVEL ⑮ switch. A sweep should then appear. The sweep is unstable at a point near the mechanical center of the LEVEL ⑭ control. This is not abnormal and the sweep will become stable by slightly turning the LEVEL ⑮ control in either direction. Brightness of the trace will increase upon the start of sweep.

Adjust the INTENSITY ① control for proper brightness. The start of the sweep will be at the center of the CRT screen. Turn the H POSITION ⑳ control counterclockwise so that the sweep begins at the left side of the graticule. Then, turn the TIME/DIV ⑱ switch and VARIABLE ⑱ control and check for a change in sweep time.

— OPERATION FROM SIGNAL COUPLING TO TRIGGERING —

SIGNAL COUPLING

Now, let us try to display the wave-form of the calibrating voltage on the CRT.

Connect the CAL OUT 0.02V to the INPUT connector on CH 1 through a coaxial cable with BNC type connectors at each end. Set the controls as follows.

MODE	CH 1
VOLTS/DIV ⑧ (CH 1)	5 mV
VARIABLE ⑧ (CH 1)	CAL position

Set the AC-GND-DC⑦switch to DC and the TIME/DIV ⑱ switch to approximately 2 mSEC. A square wave from with a vertical amplitude of 4 division will appear. Then, turn the VOLTS/DIV⑧switch, step by step, in the counter-clockwise direction. The vertical amplitude will be attenuated. Also turn the VARIABLE⑧control counter-clockwise and check that the vertical amplitude will be continuously attenuated. Return the VARIABLE⑧control to the CAL position, set the VOLTS/DIV⑧switch to the 50 mV position and connected the BNC lead to the CAL 0.2V to the INPUT connector on CH 1. The vertical amplitude will again become 4 division.

Through the above steps, the relationship between the input signal, VOLTS/DIV⑧switch and VARIABLE⑧control can be understood.

Since the above operations have been performed with a free running sweep, the waveform will not stationary and observation of the trace is very difficult. In addition, when the TIME/DIV ⑱ switch is turned clockwise, thus increasing the sweep speed, to magnify a part of the trace, the trace will appear as a belt. If a triggered sweep is used, this problem can be alleviated.

PRIOR TO TRIGGERING

It is necessary to determine the following operating conditions prior to performing triggered sweep operation.

(1) Type of trigger source internal (INT NORM, INT CH 2 ONLY) trigger or external (EXT, EXT ÷ 10) trigger ?
Refer to the description on the types of trigger signal sources (SOURCE ⑫) in this manual.

(2) Method of coupling trigger signal to the trigger circuit; AC coupling, LF REJ coupling, HF REJ coupling or DC coupling.
Refer to the description on trigger signal input coupling (COUPLING ⑬).

(3) Selection of triggering point; positive slope or negative slope ? (Refer to Fig. 2—8.)

Assuming that the AC coupling, internal trigger mode is to be used and the trace is to be triggered by a positive slope, set the SOURCE ⑫ to INT, COUPLING ⑬ to AC and SLOPE ⑭ to +.

TYPES OF TRIGGER SIGNAL SOURCE (SOURCE ⑫)

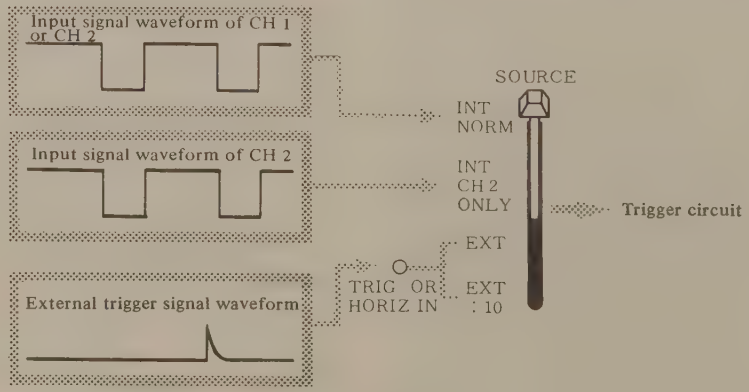
To observe an input signal as a stationary waveform (triggered sweep), it is necessary to apply the input signal (called the trigger signal) itself or a signal which has a direct time relationship (multiplication by an integer) with the input signal, to the trigger circuit, to produce a trigger pulse which can be used to drive the sweep circuit.

In the internal trigger mode, the SOURCE ⑫ switch is set to the INT NORM or INT CH 2 ONLY positions and a part of the input signal applied to the INPUT connector is coupled internally (from the vertical deflection system) to the trigger circuit. (Refer to Fig. 2–5) Whereas, in the external trigger mode, the SOURCE ⑫ switch is set to the EXT or EXT ÷ 10 positions and the input signal itself or a separate signal, time-related to the input signal, is coupled externally to the trigger circuit.
(In the external sweep mode, turn the SOURCE ⑫ switch to the EXT or EXT ÷ 10 positions.)

INTERNAL TRIGGER

Since, in the internal trigger mode of operation, a part of the input signal is internally coupled from the vertical deflection system to the trigger circuit, an input signal of low voltage applied to the INPUT connector is amplified to a proper level and automatically fed into the trigger cir-

Fig. 2–5



cuit. This mode features simplicity of operation and unlike the external trigger mode, output impedance of the trigger signal source does not decrease. For this reason, this method is convenient for normal measurements.

INT NORM mode is particularly used for a single CH 1 or CH 2 observation. For a dual trace (ALTER or CHOP) or sum-difference type observation, positive triggering can not be accomplished because the trigger signal waveform becomes complicated.

Hence, set the SOURCE ⑫ switch to INT CH 2 ONLY for the dual trace or sum-difference type observation. In this way, the sweep can be positively triggered from a trigger signal derived from the input signal to CH 2. However, then the CH 2 POLARITY ⑥ switch is set to INVERT to invert phase of the waveform on the CRT screen, the polarity switching by the SLOPE ⑭ switch will be done in opposition to the indication.

EXTERNAL TRIGGER

The external trigger mode has the disadvantage described above in connection with the feature of internal trigger, however, it provides the following important features.

First, this mode of operation is not affected by the operation of the vertical deflection system. In internal trigger operation, for example, signal voltage applied to the trigger circuit varies, depending on the setting of the VOLTS/DIV ⑧or V POSITION ⑩ switch. In some cases, depending on the waveform of the input signal, it is required to readjust the LEVEL ⑮ control each time those switches are adjusted. In external trigger operation, positive triggering can be expected even after adjusting the knobs for the vertical deflection system after the signal has once been triggered, unless of course, the waveform of the external trigger signal changes.

In the event that it is desired to start the sweep before or after the input signal, the external trigger mode provides this type of observation as long as a signal, displaced the desired interval, is available as a trigger source and is coupled to the TRIG OR HORIZ IN ⑯ connector.

When the SOURCE ⑫ switch is set at EXT, if the external trigger signal is too large, the adjustment of trigger point by means of the LEVEL ⑮ control can not be done satisfactorily. In such a case, if the SOURCE ⑫ switch is set to EXT ÷ 10, the trigger signal is attenuated and the adjustment of the trigger point is possible made.

INPUT COUPLING OF TRIGGER SIGNALS (COUPLING ⑬)

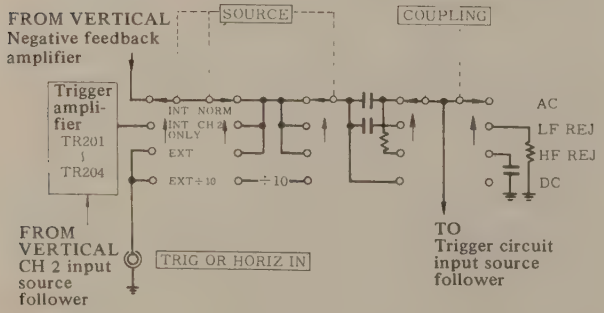
The COUPLING ⑬ switch is used to select the type of coupling of the trigger signals to the trigger circuit. It has four positions; AC, LF REJ, HF REJ and DC — As shown in Fig. 2—6, these positions represent AC coupling (AC), coupling through a high pass filter — differenciator (LF REJ), coupling through a low pass filter — integrator (HF REJ) and DC coupling (DC). This switch selects the proper position to provide a stable trigger operation depending upon the trigger signal (DC, AC, DC superimposed with other waveform, waveform superimposed with low frequency noise or waveform superimposed with high frequency noise). Functions in each of those ranges will now be described.

In addition, the COUPLING ⑬ switch is also used to select the type of input signal coupling in the case of external sweep operation. In this case, however, positions LF REJ and HF REJ can not be used.

AC

In this range, as seen in Fig. 2–6, trigger signals are fed into the trigger circuit by means of AC (capacitance) coupling, thereby, the DC component of the trigger signal is eliminated. The triggering operation is accomplished only by the remaining AC component. This means that a stable trigger can be provided regardless of the DC component of the trigger signal. In general, this range is the most convenient for practical measurement. When the frequency of the trigger signal is 10 kHz or lower, triggering is rather difficult using this range.

Fig. 2–6



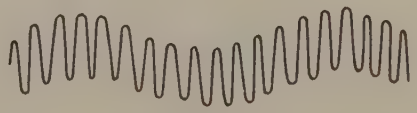
LF REJ

As shown in Fig. 2–6, the trigger signals are coupled through a high pass filter to the trigger circuit, thereby, low frequency (approximately 30 kHz or lower) trigger signals or low frequency noise superimposed on a trigger signal will not pass thru the circuit. Only the high frequency component of trigger signal is coupled to the trigger circuit. For example, when a waveform, as shown in Fig. 2–7, which is superimposed with low frequency noise, is observed, and a comparatively stable triggering operation can be provided in this range.

HF REJ

As shown in Fig. 2–6, the trigger signals are coupled through a low pass filter to the trigger circuit and, contrary

Fig. 2–7



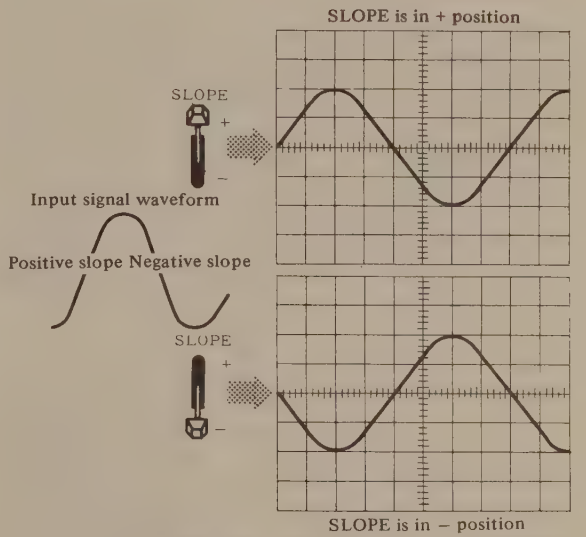
to the LF REJ, high frequency trigger signals (approximately 10 kHz or higher), or high frequency noise superimposed on a trigger signal can not pass thru the circuit. Only low frequency components can pass through it. This means that a stable trigger operation can be provided even for an input signal on which a high frequency noise is superimposed.

DC

Since the trigger signal is directly coupled to the trigger circuit as shown in Fig. 2–6, the sweep can be triggered from a DC signal. In this case, the DC level applied to the trigger level varies upon turning of the V POSITION ⑩ control, then the trigger level will change. This means that movement of the vertical position to a great extent will cause the trigger circuit to be disabled. When the input signal waveform in within the display area of the CRT screen, the sweep can be triggered by adjusting the LEVEL ⑮ control.

When the SOURCE ⑫ switch is set to INT CH 2 ONLY, the instrument always operates in the AC-coupled mode even if the COUPLING ⑬ switch is set to DC.

Fig. 2–8



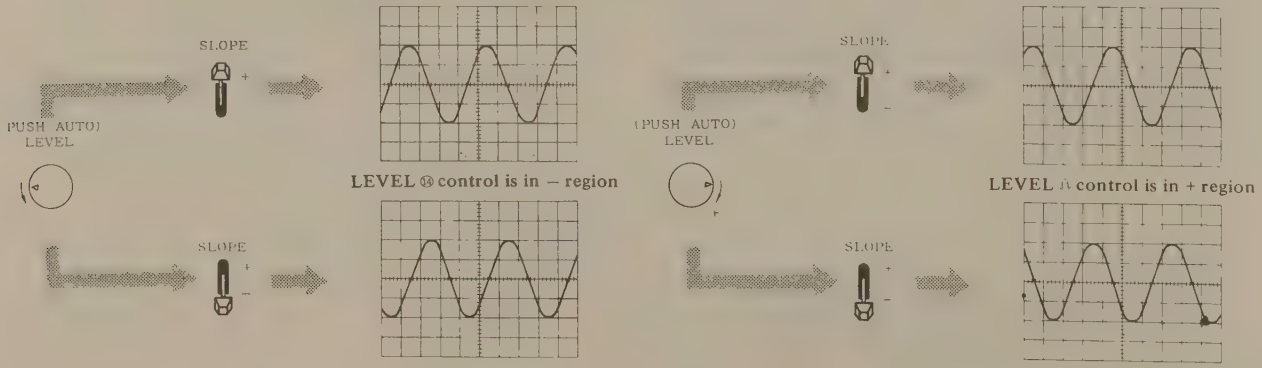
TRIGGERING PROCEDURES (1)

Upon completion of the steps described so far, the trigger can now be adjusted with the LEVEL ⑮ control. Adjust this control slowly. The input signal is triggered at approximately the mechanical midpoint of the control. The lamp ⑰, which is lighting, will go off, thus indicating that the triggering operation is being performed. Then, adjust the LEVEL ⑮ control as shown in Fig. 2–9.
Although Fig. 2–8 shows a sine wave, it should be understood as an example. It is, therefore, possible to continuously change the trigger point in the case of a square wave. The adjustable range of the triggering point of this instrument covers approximately 90% of the slope of the input signal. (for a sine wave at approximately 1 kHz and vertical amplitude of 8 division.)

Next, turn the VOLTS/DIV ⑧ switch of CH 1 counterclockwise to set the vertical amplitude on the CRT screen to approximately 0.5 division. In this case, the sweep operation may go into a free running operation. In this case, re-adjust the LEVEL ⑮ control for a stable triggering operation.

In this mode of operation — the auto mode, the sweep will freerun in the absence of a trigger signal or when the LEVEL ⑮ control is set to a point beyond the triggering point. Therefore, use the auto position whenever a free

Fig. 2–9



running sweep is required, for example, to check the ground level.

However, it should be noted that, in the auto position, triggering will not be performed with trigger signals of 50 Hz or lower. Then, the triggered mode of operation, which will be described in the following paragraph, should be used.

TRIGGERING PROCEDURES (2)

Pull the (PUSH AUTO) LEVEL ⑮ switch to select the triggered mode. Similarly to the auto mode, triggering will occur upon adjustment ofthe LEVEL ⑮ control.

In this mode, the sweep will stop and the instrument will be in standby, with a spot, in the absence of a trigger signal or when the LEVEL ⑮ control is set beyond the triggering point. (The spot will, however, not appear unless the SPOT FINDER ⑰ pushbutton is pushed.)

— DUAL TRACE OPERATION AND MEASUREMENT OF SUM AND DIFFERENCE —

DUAL TRACE OPERATION

First place the MODE 5 switch in the ALTER position. When the V POSITION ⑩ control on CH 2 is turned to its mechanical midpoint, a calibrating voltage waveform and a trace will appear on CH 1 and CH 2, respectively, as a result of the operation instructed in the previous paragraph. Then, set the AC-GND DC⑦switch on CH 2 to the DC position and connect the calibrating voltage to the INPUT connector on CH 2 through a coaxial cable with BNC type connectors. Dual traces should now be observed on the CRT screen. As the SOURCE ⑫ switch is in the INT NORM position, triggering will become unstable if the traces from CH 1 and CH 2 are separated by adjusting the V POSITION ⑩ control. Then, turn the SOURCE ⑫ switch to the INT CH 2 ONLY. Stable triggering can be provided by using a trigger signal derived from the input signal on CH 2.

Next, turn the TIME/DIV ⑱ switch counterclockwise. Simultaneous viewing of both traces in now impossible because CH 1 and CH 2 are alternatively swept.
Therefore, simultaneous viewing of a low frequency input signal should be performed in the CHOP mode as stated below.

Place the MODE⑤switch in the CHOP position. Even if the sweep speed is lowered, simultaneous observation of both traces can be provided. Contrary to the ALTER mode, the trace may become a dotted line when the sweep speed is set higher (TIME/DIV ⑱ switch set to approximately 50 μsec/div or higher, thus causing difficulty in observation).

Trigger control is performed similar to that of the ALTER mode. Setting the COUPLING ⑬ switch to HF REJ will provide more stable triggering.

In this way, dual trace operation can be provided in all TIME/DIV ranges upon proper selection of the ALTER or CHOP mode.

MEASUREMENT OF SUM AND DIFFERENCE

Following the previous step, set the MODE ⑤ switch to ADDED. A sum of the CH 1 and CH 2 input signals can be observed. Then, pull the CH 2 POLARITY ⑥switch. Polarity of the CH 2 input signal is reversed and added to the CH 1 input signal. Therefore, the resultant signal

observed is a difference between the two input signals, that is, CH 1 + (–CH 2).

In addition, if the input signal is equally applied to the CH 1 and CH 2 input circuits by adjusting the VOLTS/DIV ⑧ and VARIABLE ⑧ controls, a trace will appear on the CRT screen. If the signal level applied to CH 1 is higher than that on CH 2, a positive signal is displayed. Whereas, if the input signal level on CH 2 is higher, a negative waveform will appear.

When the MODE ⑤ switch is set in the ADDED position, although it is possible to perform adjustment of the vertical position of the trace by either the CH 1 or CH 2 V POSITION ⑩ controls, serring of those controls in extreme positions may deteriorate linearity of the trace. Hence, it is recommended to set each of the V POSITION ⑩ control will be reversed, but this is not abnormal.

When the CH 2 POLARITY ⑥ switch is pulled, adjustment of vertical position by the CH 2 V POSITION ⑩ control will be reversed, but this is not abnormal.

— MAGNIFIED SWEEP —

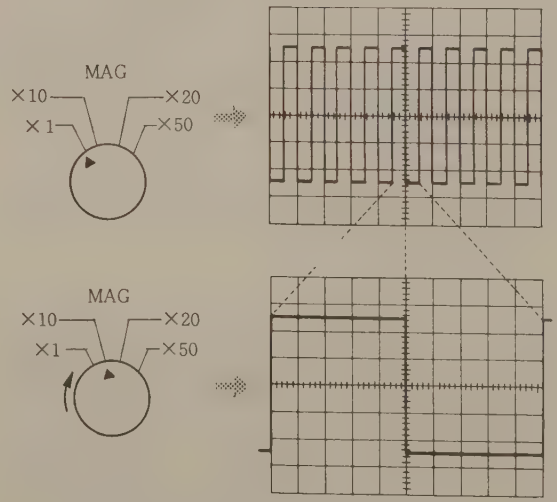
If it is required to observe a trace of an input signal, part of which is timemagnified, it will be necessary to increase the sweep speed. However, if the portion of the waveform which is delayed from the start of the sweep is magnified, the desired portion of the trace will go off of the CRT screen even if the sweep speed is increased.

To observe a particular part of the display, set it on the center of the CRT screen, and place the MAG switch ㉒ to, for example, the x10 position. Then, the display will be magnified as shown in Fig. 2–10. The length of trace in this case will appear as approximately 10 division on the CRT screen, but its actual length is approximately 100 division. By turning the H POSITION ⑳ and FINE ⑳ controls, the length of the trace can be observed.

In magnified sweep operation, the actual sweep time can be obtained by multiplying the TIME/DIV ⑱ value by 1/10. Therefore, the maximum sweep time is changed from 0.2 μsec/div (unmagnified) to 0.2 μsec/div x1/20 = 0.01 μsec/div.

In this way, magnified sweep operation provides increased sweep speed but less intensity. In addition, there is the possibility of failing to multiply the sweep time by 1/10. For these reasons, it is recommended that use of

Fig. 2–10



the magnified sweep operation be avoided except for the following cases.

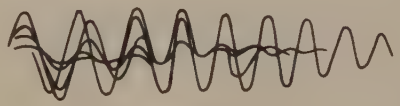
(1) When it is required to magnify a portion of the sweep which is spaced considerably away from the start of sweep.

(2) When it is required to provide a sweep speed higher than 0.2 μsec/div.

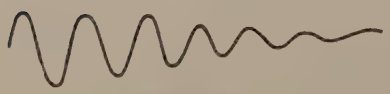
—SINGLE SWEEP OPERATION —

If a conventional repetitive sweep is used for the measurement of a transient such as a discharge waveform or a waveform from relay contracts, the traces are superimposed as shown in Fig. 2–11. In this case, a proper measurement can be provided by means of using a single sweep in which only one sweeping operation is performed. In the single sweep, since the trace disappears immediately after the end of sweep, photographic recording of the trace, for analysis, is usually employed.

Fig. 2–11



Repetitive sweep



Single sweep

The basic operation of single sweep using the calibrating voltage as the input will now be described. Apply the calibrating voltage to the input connector and set the relevant controls as follows.

MODE (TOP panel)	NORMAL
(PUSH AUTO) LEVEL ⑭	PULL
TIME/DIV ⑱	Desired position
VOLTS/DIV ⑧	Desired position

After completion of the above procedures, provide a positive trigger and set the MODE switch to the SINGLE position. Upon pushing the RESET switch, a single sweep is carried out.

Next, remove the calibrating voltage from the INPUT connector and push the RESET switch. The instrument will go into a standby status (ready for sweeping (a single sweep) upon reception of a trigger signal). The lamp in the SPOT FINDER ⑰ button will light to indicate the standby status. A single sweep is carried out upon application of the calibrating voltage. The standby status is provided only in case of a triggered mode. (In some cases, the standby status can not be provided at a point in the center position of the LEVEL ⑮ control; if this occurs, turn the LEVEL ⑮ control slightly in either direction.) In the ALTER mode, however, the dual trace, simultaneous single sweep operation is not available.

As in the internal trigger mode, a single sweep operation, triggered from an external signal applied to the TRIG OR HORIZ IN ⑯ connector can also be provided.

—X–Y SCOPE OPERATION—

Examples of the X–Y scope applications will be de-

scribed in Chapter 4. The description of this chapter is limited only to an outline of the X–Y scope operation.

(1) First, set the TIME/DIV ⑱ switch to EXT HORIZ. A spot will appear if the H POSITION ⑳ control is turned counterclockwise.

(2) Move the spot to the center of the CRT screen by adjusting the V POSITION ⑩, H POSITION ⑳ and FINE ⑳ controls.

(3) Set the following relevant controls.

MODE	⑤		CH 1
VOLTS/DIV	⑧	(CH 1)	0.1
VARIABLE	⑧	(CH 1)	CAL
AC-GND-DC	⑦	(CH 1)	AC or DC
SOURCE	⑫		EXT
COUPLING	⑬		AC

(4) Then, connect the CAL OUT 2V terminal to the CH 1 INPUT connector and TRIG OR HORIZ IN ⑯ with the attached BNC type coaxial cable.

Two spots will appear diagonally on the CRT screen after the above steps have been taken. This is a Lissajous' figure of a phase difference of zero at 1 : 1 frequency ratio.

If signals of different phase and frequency are applied in line of the CAL OUT, a variety of Lissajous' figures will appear. (Refer to Fig. 3–22.)

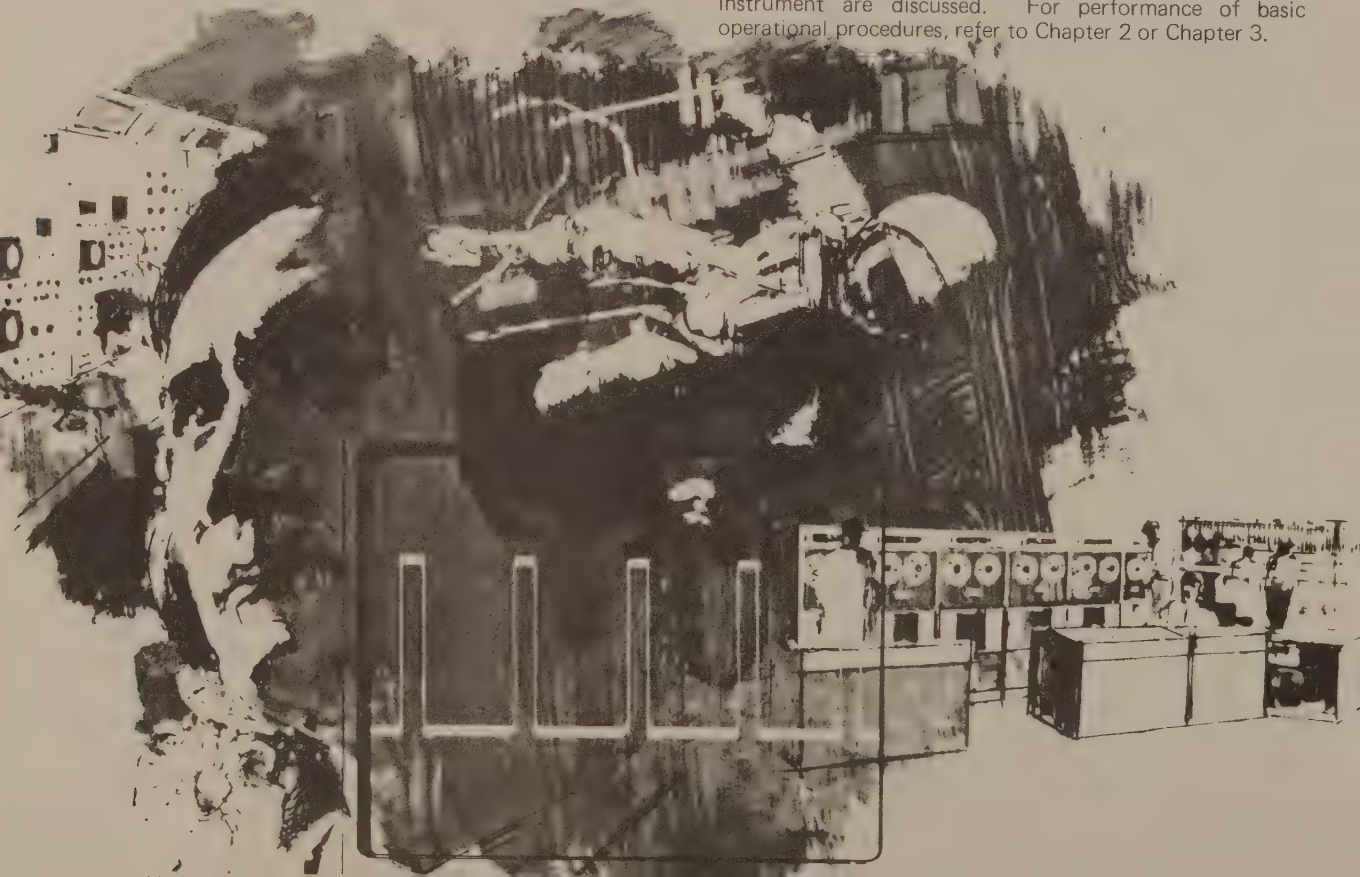
As the sensitivity decreases to 1/10 when the SOURCE ⑫ selector is switched from EXT to EXT ÷ 10, control the external sweep input level by setting the selector to EXT ÷ 10 whenever the level is too high. In addition, this instrument can be used for an X–Y scope operation in the following manner. Namely, in the foregoing steps, the signal applied to the TRIG OR HORIZ IN ⑯ is now coupled to CH 2 INPUT connector and the SOURCE ⑫ selector is set to INT CH 2 ONLY. The signal applied to CH 2 is introduced to the horizontal amplifier to provide a horizontal deflection of the electron beam. In this case, the sensitivity will become approximately four times as high as the CH 2 VOLTS/DIV ⑧ indecation and frequency bandwidth will be DC to 3 MHz at –3dB which is similar to the foregoing case. In either case, the horizontal amplifier will automatically have the sensitivity increased to 20 times when the TIME/DIV ⑱ switch is set to EXT HORIZ.

The MAG ㉒ control in this particular case will be disabled.

MEMO

CHAPTER 3 MEASUREMENT PROCEDURES

In this section measurements and applications of the instrument are discussed. For performance of basic operational procedures, refer to Chapter 2 or Chapter 3.



CONNECTION OF INPUT SIGNALS

The input impedance of the instrument at the INPUT connector consists of a resistance of 1 MΩ and a parallel capacitance of 25 pF or less. The input impedance will change to a resistance of 10 MΩ shunted by a parallel capacitance of 18 pF or less when the provided probe is used, thus reducing possible interference in the circuit under test to a minimum.

There are several methods of coupling the instrument to a signal source. These include the use of a conventional insulated wire, shielded wire, probe and coaxial cable. The type of coupling should be determined in accordance with the following factors.

Output impedance of the input signal source
Amplitude and frequency of input signal
Induction from external circuit
Distance between the instrument and signal source

Table 3–1 classifies the coupling methods according to the type of input signal.

Table 3–1

Type of Input Signal	Method of Coupling		Insulated wire	Shielded wire	Probe	Coaxial cord	Others
Low frequency	Low impedance	Near	O	O	O		
		Distant		O		O	
	High impedance	Near		O	O		
		Distant		O			
High frequency	Low impedance	Near			O	O	
		Distant				O	
	High impedance	Near			O	O	
		Distant					O

Each type of coupling will now be described.

USE OF INSULATED WIRE

Remove insulation from each end of the insulated wire and couple it to the INPUT connector (connect an insulated adapter (BNC-BP-12D) to the INPUT connector, then connect the wire to the adapter.) The signal from the circuit under measurement can be coupled to the instrument. This method features simplicity and the input signal

is fed into the instrument without attenuation.

If the wire is too long or there is a high intensity electric field around the wire, an inductive signal will be present, thus affecting the result of the observation. The degree of interference will become greater when the output impedance of the signal source is high.

In addition, stray capacitance to ground is considerably high. The input capacitance is the sum of the stray capacitance and the input capacitance of the instrument. In comparison to measurements using a 10 : 1 attenuator probe, the circuit under test will be more affected by the input capacitance.

For example, assume that the output impedance of a signal source is 1 kΩ, the input signal frequency is 1 MHz and the sum of the input capacitance (stray capacitance) and input capacitance of the instrument is 100 pF. An impedance of 1.6 kΩ which actually does not affect the circuit under test as a load.

Therefore, coupling, using insulated wire is suitable for an input signal source of low output impedance and low frequency.

USE OF SHIELDED WIRE

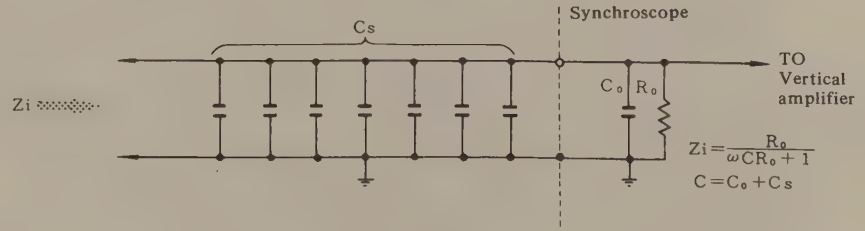
Interference from an external field can be removed by using shielded wire in place of insulated wire. However, this method is not suitable for measuring high frequency signals because the capacitance of the shielded wire is quite large; 50 pF/m to 100 pF/m.

This method eliminates the effects of electrostatic induction.

USE OF PROBE

A 10 : 1 attenuator probe is furnished. As seen from Fig. 3–2, the effects of an external field are eliminated by

Fig. 3–1 Input impedance when insulated wire is used



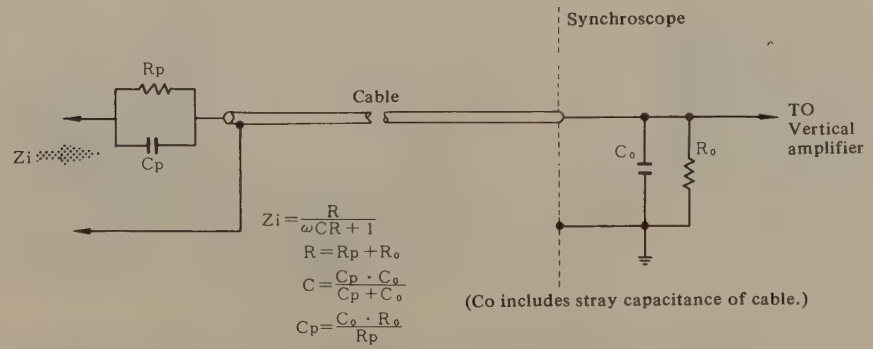
using a shielded lead. In addition, a wideband attenuator is formed with an attenuating resistance of Rp, and parallel capacitance Cp, input resistance Ro of the instrument and its parallel capacitance Co. Because of this attenuator, this method provides statisfactory measurements of signals having high output impedance and high frequency. As the input impedance of the probe is approximately 13 pF, the input impedance for measuring signal at 1 MHz is 10.61 kΩ, which is considerably higher than that of insulated wire. However, there are some disadvantages, for example, the input signal is attenuated to 1/10 and there is a limited length of cable. As an alternate method, in which the input capacitance is reduced but the input signal not attenuated, a cathode follower probe is used.

When the 10 : 1 probe is used for high frequency measurements, provide a ground connection for the probe by connecting its grounding clip or bayonet adapter to a point close to the signal source in order to remove waveform distortion.

USE OF COAXIAL CABLE

When the output impedance of the signal source is 50 Ω , 75 Ω , 93 Ω or 125 Ω , a coaxial cable having a characteristic impedance which meets the output impedance can be used to transmit signals, with minimized attenuation. The impedance matching should be provided at the INPUT connector of the instrument as shown in Fig. 3–3 to prevent high frequency waveforms from being distorted.

Fig. 3–2 Input impedance when probe is used



OTHER METHODS

When it is required to measure input signals of high frequency and high impedance over a long distance, an impedance converter is used to convert the output impedance of the signal source to the impedance of the coaxial cable (for example, 75 Ω), enabling the measurement to be correctly performed.

A transformer can be used as the impedance convertor, when the bandwidth of the signal is narrow. When a wide bandwidth is required, a cathode follower circuit is suitable. (Refer to Fig. 3–4.)

If it is possible to obtain a high level output from the circuit under test, a voltage divider network matching the characteristic impedance of the coaxial cable may be used for the transmission of signals as shown in Fig. 3–5.

Fig. 3–3 Transmission of signal when coaxial cable is used

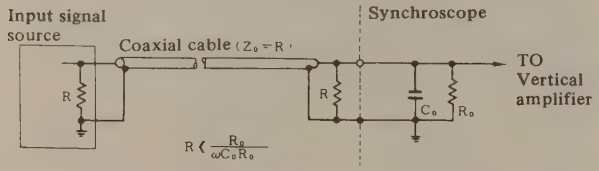


Fig. 3–4 Transmission of signals over a distance (1)

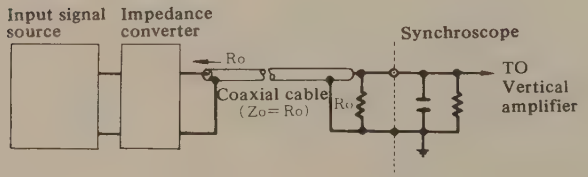
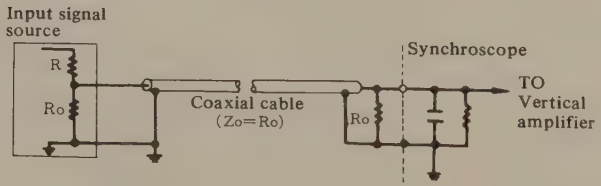


Fig. 3–5 Transmission of signals over a distance (2)



USE OF PROBE

CONNECTION

Unlike conventional synchroscopes, the INPUT connector of this instrument is located on the top panel. Normally, a probe is directly coupled to the INPUT connector. In this case, the probe will stand vertically on the top panel as seen in Fig. 3–6.

In some cases, depending upon the conditions of operation, the presence of probe standing vertically on the top panel may hinder handling of the instrument. In such a case, the use of a specially designed L-shaped adapter furnished with the instrument to permit the probe to be horizontally mounted as shown in Fig. 3–7 is recommended. The probe can be rotated together with the L-shaped adapter.

PRECAUTIONS FOR USE OF L–SHAPED ADAPTER

Because of stray capacitance of 2 or 3 pF within L-shaped adapter, the phase of the probe output with the adapter will be different from that of a directly-coupled probe output. Hence, it is required to perform recalibration of phase of the probe for proper observation whenever the type of connection of the probe is changed.

PROBE ACCESSORIES AND THEIR USES

An accessories kit is available as listed in Table 3–2 to provide convenient observation with the synchroscope. The probe hook is used as shown in Fig. 3–8.

Fig. 3–6 Probe directly connected to the INPUT connector

Fig. 3–7 Probe connected to the INPUT connector with L-shaped adapter

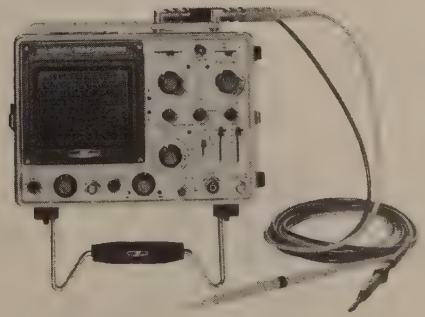
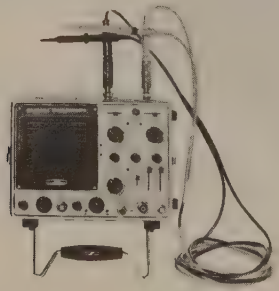


Table 3–2

Accessories	Q'ty	Purpose
Retractable hook tip	2	Hooks circuits under test by retrating.
Straight tip	2	Used to touch the narrow circuit.
Clip tip with lead	2	Cliped to the point being measured.
Screw adaptor	2	2.5 mm to 4 mm adaptor for all conventional tips.
Ground lead	2	Necessary for high frequency measurement, insert a tip into a probe neck.
Probe hook	2	Used to fasten the probe to the connector of the probe.

Fig. 3–8



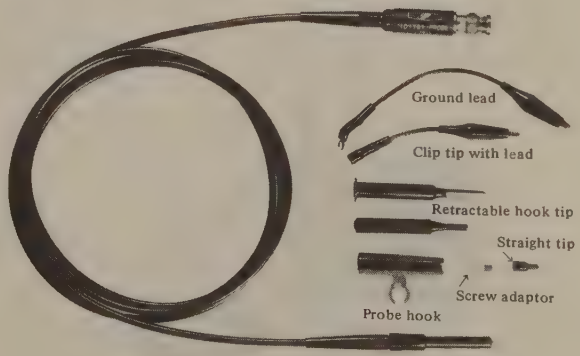
PHASE CALIBRATION FOR PROBE

It is necessary to correctly calibrate the phase of a probe to prevent observation of the wrong waveform. Phase of the probe may vary when the probe is shocked. It is, therefore, necessary to check the probe phase whenever the probe receives a shock.

Probe phase calibration can be accomplished in the following manner.

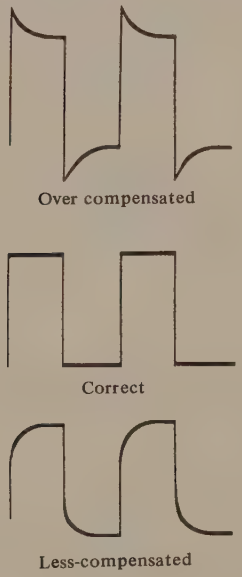
First, set the VOLTS/DIV switch to 5 mV and connect

Fig. 3–9 Probe



tip of the probe to the CAL OUT 0.2V terminal, thus making the amplitude on the CRT screen 4 divisions. Then, turn the variable capacitor shown in Fig. 3–9 in both directions. The leading edge of the waveform will vary as shown in Fig. 3–10. Set the phase for the correct phase waveform.

Fig. 3–10 Probe phase calibration



VOLTAGE MEASUREMENTS

QUANTITATIVE MEASUREMENT

In case a quantitative measurement of voltage is carried out, always turn the VARIABLE control fully clockwise so that the voltage can be read directly from the VOLTS/DIV indication. If it is necessary to measure a voltage with the VARIABLE control set elsewhere position, the quantitative measurement can be carried out as follows.

(1) First, note the amplitude of the input signal voltage on the CRT screen.

(2) Then keep the VOLTS/DIV and VARIABLE controls as they are and apply a calibrating voltage to the INPUT connector. Connect the CAL OUT for a proper amplitude, of the instrument and calculate the vertical deflection factor at this time by using equation (3–1) below.

$$\text{Vertical deflection factor (V/cm)} = \frac{\text{Indication of CAL OUT (V)}}{\text{Vertical amplitude of calibrating voltage (div)}} \quad \ldots\ldots\ldots\ldots\ldots (3\text{–}1)$$

When the vertical deflection factor is determined by the equation (3–1), the input signal voltage can be obtained by the equation (3–2).

$$\text{Input signal voltage (V)} = \text{Vertical deflection factor (V/div)} \times \text{Vertical amplitude (div)} \quad \ldots\ldots\ldots\ldots\ldots (3\text{–}2)$$

DC VOLTAGE MEASUREMENT

The instrument can be used as a DC voltometer.

Operate the instrument in the free running mode and increase the sweep speed so that the trace of sweep will not

flicker.

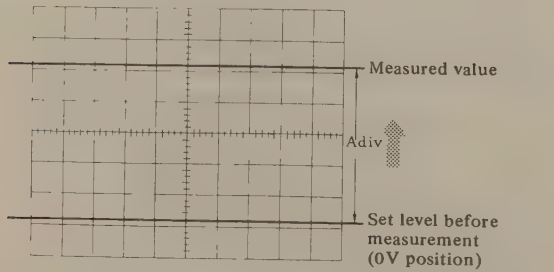
Set the AC-GND-DC switch to the GND position. As this trace will be used as 0 V in the measurement as shown in Fig. 3–11, position the trace in a proper position on the CRT screen. Set the AC-GND-DC switch to the DC position and couple the INPUT connector to the voltage to be measured. Read the amount of movement of the trace on the graticule.

If the trace goes off of the CRT screen when the INPUT connector is coupled to the circuit under measurement, reset the VOLTS/DIV switch to move the trace to a convenient position. If the trace moves upward, the voltage polarity is positive, and if it moves downward, the polarity is negative. Assuming that the amount of movement of the trace is A (div), then the voltage can be given by the equations (3–3) and (3–4).

When the 10 : 1 probe is used:

Voltage (V) = VOLTS/DIV indication (V/div) x Amplitude (div) x 10 ..... (3–3)

Fig. 3–11



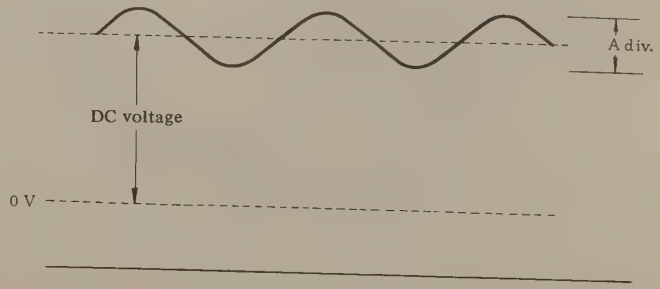
When the signal is fed directly into the INPUT connector:

Voltage (V) = VOLTS/DIV indication (V/div) x Amplitude (div) ..... (3–4)

AC VOLTAGE MEASUREMENT

When a DC voltage is superimposed with an AC voltage as shown in Fig. 3–12, set the AC-GND-DC switch to DC. If the DC voltage is higher than the AC voltage, the vertical position of the AC voltage is moved off of the CRT screen because of the presence of the DC voltage. In this case, the trace may be returned to the CRT screen by adjusting the POSITION control. However, the use of this method should be avoided because of the resultant errors in measurement. Also, it is possible to display the AC trace on the CRT screen by selecting the VOLTS/DIV position. This method does not, however, provide an accurate measurement because the amplitude of the signal trace becomes too low.

Fig. 3–12



Set the AC-GND-DC switch to the AC position. The DC voltage is now rejected by a coupling capacitor and the AC voltage can be amplified to a sufficient level for the measurement. Assuming that the amplitude of the AC voltage is A (div), the AC voltage can be calculated by using equation (3–3) or (3–4). (In the AC measurement, the amplitude is attenuated by 3 dB at approximately 3 Hz or by 3 dB at 0.3 Hz when the probe is used.)

The AC voltage obtained from equation (3–3) or (3–4) is a peak-to-peak value. This value can be converted to an RMS value by using the equation (3–5).

$$\text{Voltage (V rms)} = \frac{\text{Voltage (Vp-p)}}{2\sqrt{2}} \quad \ldots\ldots\ldots\ldots\ldots (3\text{–}5)$$

MEASUREMENT OF CURRENT WAVEFORM

Voltage is the only phenomenon which can be observed directly with a synchroscope. Therefore, it is required to convert electrical phenomenon other than voltage, mechanical vibration or any other phenomenon into a voltage, then feed it into the IMPUT connector.

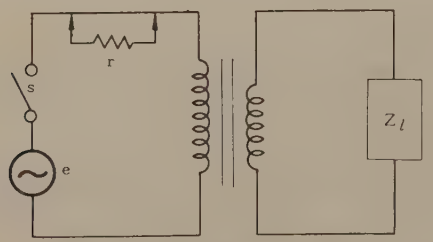
To view a current waveform, insert a known resistance into the circuit under test and observe the variations in the voltage across the resistance on the synchroscope, then calculate the current value from the $V = IR$ relationship. The inserted resistor should have a resistance which will not disturb the normal operating conditions of the circuit under test. In case it is impossible to insert such a resistor due to restrictions in the circuit, a current probe capable of measuring current without opening the circuit is available.

In case the circuit is isolated from ground as shown in Fig. 3–13, current measurement can not be carried out properly unless the scope is provided with a couple of input connectors, that is, a differential type amplifier is required.

A differential measurement can be carried out with this instrument as described in Section 3, Dual Trace Operation and Measurement of Sum and Difference in the following manners.

Set the MODE switch in the ADDED position and CH 2 POLARITY switch to the INVERT position, then connect the probe of CH 1 and CH 2 to the other side. Next, set the VOLTS/DIV switch of CH 1 and CH 2 to the same position, and a current waveform developed across r can be observed.

Fig. 3–13



TIME MEASUREMENTS

MEASUREMENT OF TIME INTERVALS

Set the VARIABLE control to the CAL position, then the time interval between two orbitrary points on a trace can be obtained directly from the TIME/DIV indication.

First, set the MODE to the NORMAL position and the VARIABLE control to the CAL position, then perform triggering. Now, select a convenient TIME/DIV position for the measurement of the time interval between two points as shown in Fig. 3–14, then note the reading T and obtain the time interval from the equation (3–6).

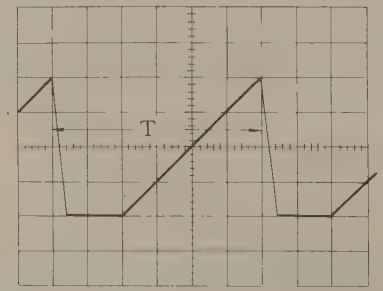
Time (sec) = TIME/DIV indication (sec/div)
x Length of interval on CRT screen (div)
x Inverse number of magnifying factor ..... (3–6)

In equation (3–6), the inverse number of the magnifying factor is 1 when the sweep is not magnified, and 0.1, 0.05, 0.02 when magnified by ten, twenty, and fifty times.

MEASUREMENT OF TIME DIFFERENCE

The measurement of the time difference between two signals can be easily measured by means of dual trace operation in the ALTER and CHOP mode.

Fig. 3–14



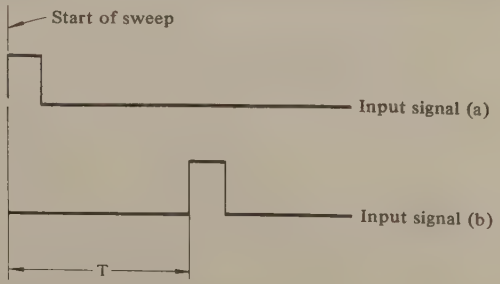
Place the SOURCE switch in the INT CH 2 ONLY position and couple the leading signal (a) to the CH 2 INPUT connector and the lagging input signal (b) to the CH 2 INPUT connector. Upon obtaining a triggered sweep, a waveform similar to that of Fig. 3–15 is observed. Note length T and calculate the time difference from equation (3–6).

OBSERVATION OF RISING OR FALLING EDGE OF A WAVEFORM

Since a signal delay cable is incorporated in the vertical deflection system of this instrument, observation of the Rising (or Falling) edge of a signal can be easily observed in the internal trigger mode as shown in Fig. 3–16 as long as the input signal has a rise (or fall) time shorter than the signal delay time of 120 nsec.

In case the rise (or fall) time is longer than the signal delay time, the observation should be accomplished in the external trigger mode.

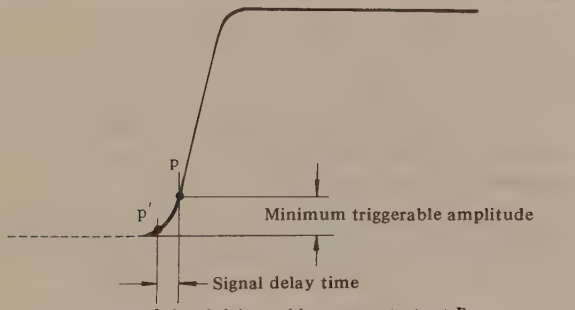
Fig. 3–15



MEASUREMENT OF PULSE WIDTH

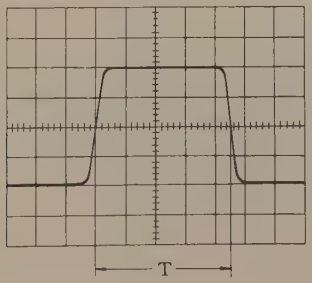
Pulse width measurement can be accomplished in the following manners.

Fig. 3–16



In the absence of signal delay cable, sweep starts at P.
When a signal delay cable is incorprated, the sweep starts at P.

Fig. 3–17 Measurement of Pulse Width



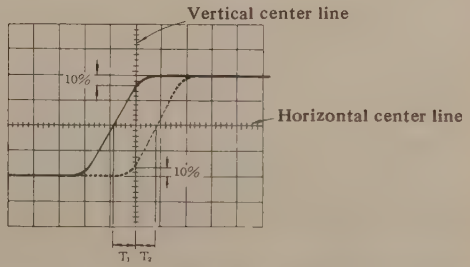
Display a pulse with a vertical amplitude of 2 div to 4 div centered around the center graticule line. Set the VARIABLE control fully clockwise and the TIME/DIV switch for a convenient horizontal width. As shown in Fig. 3–17, note the width, T, between the rising and falling edges of the pulse with the horizontal center line of the graticule, then calculate the pulse width by using equation (3–6). In the case of a very narrow pulse width, the trace should be magnified for convenience of measurement.

MEASUREMENT OF RISE (FALL) TIME OF PULSE

Similar to the pulse width measurement, the pulse trace is properly displayed in both the vertical and horizontal directions.

As shown by the solid line of Fig. 3–18, set the H POSITION control so that the 10% point, (that is, in Fig. 3–18, a point 0.4 division down from the top because the vertical amplitude is 4 cm.) will move until

Fig. 3–18 Measurement of rise (fall) time



it intersects the vertical center line of the graticule, then note the width (T1) between the intersection of the rising (or falling) edge of the trace with the horizontal center line of the graticule and the vertical center line of the graticule.

Move the trace, by using the H POSITION control, so that the 10% point from bottom of the trace will intersect the vertical center line, as shown by the dotted line of Fig. 3–18. Read the width T2 between the intersection of the rising (or falling) edge of the trace with the horizontal center line and the vertical center line. Substitute T1 + T2 in equation (3–6) and obtain the rise (or fall) time T (sec).

It should be noted that the rise (or fall) time can be obtained directly from the indication when the rise (or fall) time of the pulse is sufficiently longer than the rise time (24 nsec) of the instrument. Whereas, when the rise (or fall) time of the pulse is shorter than the rise time of the instrument, a correction should be made in accordance with equation (3–7).

$$Tr = \sqrt{T^2 - Ts^2} \quad \text{..... (3–7)}$$

Tr ; True value
T ; Measured value
Ts ; Rise time of this instrument (24 nsec)

FREQUENCY MEASUREMENT

There are three major ways of measuring frequency.

In the first method, as seen from Fig. 3–19, the time for one cycle (period) is obtained from the equation (3–6), then the frequency is calculated from the equation (3–8).

$$\text{Frequency (Hz)} = \frac{1}{\text{Period T (sec)}} \quad \text{..... (3–8)}$$

In the example of Fig. 3–19, the time for one cycle is 8 division, TIME/DIV is in the 1 μsec/div position, then the period T (sec) would be;

$$T\ (\text{sec}) = 8 \text{ division} \times 1\ \mu\text{sec/div} = 8\ \mu\text{sec}$$

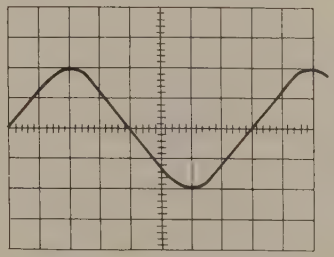
Then, the frequency (Hz) would be;

$$f\ (\text{Hz}) = \frac{1}{8} \times 10^{-6}\ \text{sec} = 125 \times 10^{3}\ (\text{Hz}) = 125\ \text{kHz}$$

In the second method, as shown in Fig. 3–20, the number of periods N is counted and the frequency can be calculated with equation (3–9).

$$\text{Frequency (Hz)} = \frac{N}{\text{TIME/DIV indication (sec)} \times 10} \quad \text{... (3–9)}$$

Fig. 3–19 Measurement of frequency (1)



TIME/DIV ; 1 μsec/div
VARIABLE ; Set to CAL position

In comparison with the first method, the measurement error can be reduced when N is a large number (30 – 50), and the accuracy of the measurement can be close to the accuracy of the sweep time. Whereas, when N is a small number, figures below the decimal point are not accurate, thus causing the error to increase.

The above two types of frequency measurement are based on time measurement. If the frequency is comparatively low (10 kHz or lower as shown in Table 1–2) and the waveform is a sine wave, square wave, triangular wave, sawtooth wave or other simple waveform, the frequency measurement can be accomplished by means of a Lissajous' figure derived by operating the instrument as an X–Y scope as described in Chapter 2.

Set the TIME/DIV switch in the EXT HORIZ position, SOURCE switch to the EXT position and the COUPLING switch to AC or DC depending upon the type of input signal, then turn the POSITION control counterclockwise to obtain a spot on the CRT screen.

Next, couple an input signal (assuming that it is a sine wave signal) of an unknown frequency to the CH 1 INPUT connector, and a signal of a known frequency (from a calibrated signal generator) to the TRIG OR HORIZ IN connector. Adjust the signal generator output and vertical deflection factor of this instrument so that the vertical and horizontal amplitudes of the trace will be about 4 division.

Change the signal generator frequency to obtain a 1 : 1 Lissajous' figure of a 1 : 1 frequency ratio should be a circle, ellipse or straight line. When it approaches the 1 : 1 ratio, the figure will continuously change from a – b – c – d – e – d – c – b – a. When it further approaches the 1 : 1 ratio, the change will become gradual and finally the figure will become stationary in one of the abovementioned

Fig. 3–20 Measurement of frequency (2)

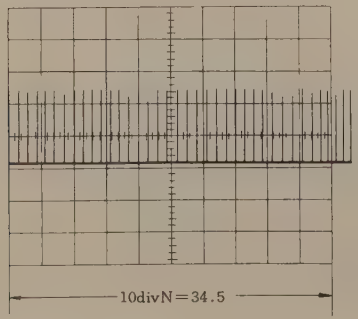
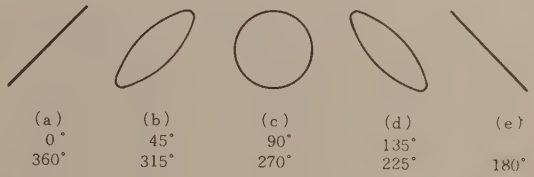


Fig. 3–21 Lissajous' figures of two sine Wave signals



configurations upon coincidence of the two frequencies.

The signal generator frequency at this time is the frequency of the signal. Error of this measurement should be equal to the error of the signal generator frequency.

When the change in figures becomes slower, the figure starting at (a) will again return to (a). The number of repetitions is the error in frequency. To discriminate whether the error is caused on the upper or lower side of the correct frequency, change the signal generator frequency slightly. It is necessary, when the signal frequency is very low, for example 1 Hz or 10 Hz, to make sure that no change in the Lissajous' figure occurs for a long period of time after obtaining a stationary figure.

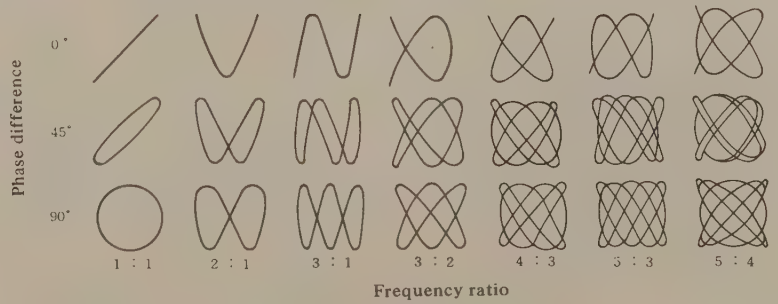
Fig. 3–22 shows a variety of Lissajous' figures derived from two sine wave signals applied to the CH 1 and CH 2 INPUT connectors at different frequency ratios. In case of an arbitrary frequency ratio, the Lissajous' figure can be drawn graphically or calculated by other methods, however, the easiest and most accurate way is to use a signal generator capable of providing a continuously variable output frequency over a wide range to provide a Lissajous' figure of 1 : 1 frequency ratio.

Fig. 3–23 shows some Lissajous' figures derived from two signals of different waveforms.

Fig. 3–23 Lissajous' figures derived from two different waveforms (1 : 1 frequency ratio)

(a) Sine wave and triangular wave (b) Sine wave and squre wave (c) Sine wave and sawtooth wave

Fig. 3–22 Lissajous' figures at various frequency ratio



PHASE MEASUREMENT

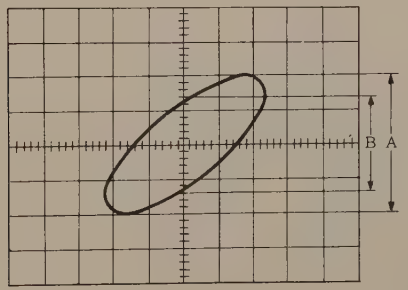
MEASUREMENT USING LISSAJOUS' FIGURES

As prescribed in connection with the frequency measurement a Lissajous' figure is derived by operating the instrument as an X–Y scope. (Refer to Fig. 3–24.) Then, the phase difference can be obtained by the equation (3–10).

$$\text{Phase angle } \sin\theta^{-1} = \frac{B}{A} \qquad \text{..... (3–10)}$$

In high frequencies, the phase distortion of this instrument causes error in this measurement. The method is used for measurement of lower than 10 kHz.

Fig. 3–24



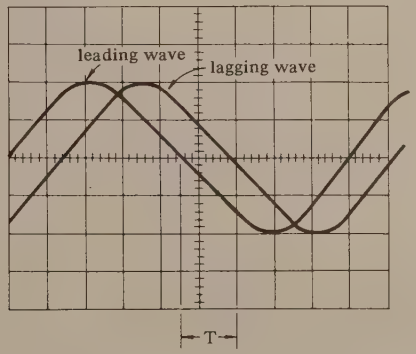
PHASE MEASUREMENT OF DUAL TRACE OPERATION (FOR TWO SIGNALS OF THE SAME FREQUENCY)

The most important thing in this method is to provide a correct trigger. It is then required that the synchroscope be operated in the external trigger or internal trigger mode with the SOURCE switch in the INT CH 2 ONLY position.

Fig. 3–25 shows an example of phase difference measurement between two-leading and lagging sine waves.
Fig. 3–26 shows an example of time measurement of a pulse in a circuit.

In Fig. 3–25, set the TIME/DIV and VARIABLE controls so that the period is 9 division for convenience of measurement. In this case, 1 division corresponds to 40° and one period is $2\pi = 360^{\circ}$, then the phase difference can

Fig. 3–25



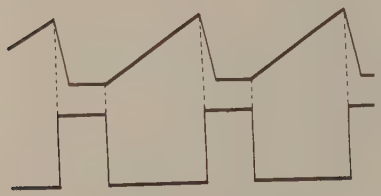
be calculated by the equation (3–11).

Phase difference (degrees) = Distance on horizontal axis T between leading and lagging waves x 40^{o} ..... (3–11)

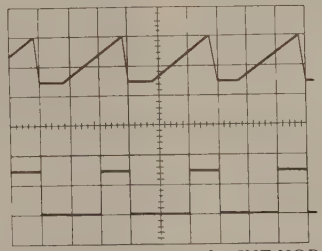
PHASE MEASUREMENT BY DUAL TRACE OPERATION (FOR TWO SIGNALS OF DIFFERENT FREQUENCY)

Fig. 3–27 shows an example of observing an output

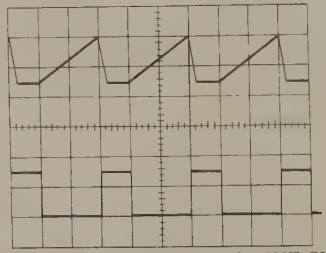
Fig. 3–26



(a) Actual phase relationship of a pulse

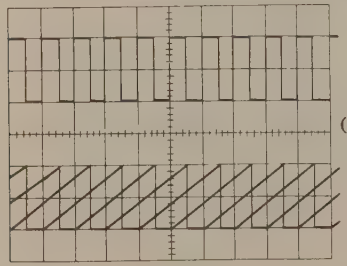


(b) When SOURCE switch is set for INT NORM position.
The phase relation may become different from its actual status and in some cases trigger may become inoperable.

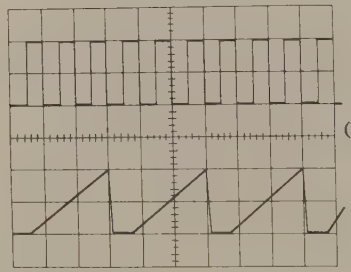


(c) When SOURCE switch is set for INT CH 2 ONLY, EXT or EXT ÷10 position.
Phase relation is correctly displayed.

Fig. 3–27 Phase measurement of two signal traces of different frequency



(a) When a squre wave is used as a trigger



(b) When a sawtooth wave is used as a trigger

waveform from the shaping circuit of the synchroscope and a sawtooth wave triggered from the said output waveform. When the two signals have different frequencies (however, the two frequencies are in an integer ratio relationship), it is necessary to trigger from the lower frequency signal. Therefore when the measurement is carried out with the SOURCE switch in the INT CH 2 ONLY condition in the internal trigger mode, it is necessary to couple the lower frequency waveform to the CH 2 INPUT connector. (Saw tooth wave in Fig. 3–27.)

If, on the contrary, a square wave is used as a trigger, the saw tooth wave will not be triggered.

MEASUREMENTS OF NON-ELECTRICAL PHENOMENA

Voltage is the only phenomenon which can be applied directly to a synchroscope for measurement. As the development of a variety of transducers capable of converting other phenomenon into a voltage advanced synchroscopes have been widely applied for various measurements including dynamic, optical temperature, or even chemical changes.

A brief explanation of some representative types of transducers will now be given below.

MEASUREMENT OF AMOUNT OF DYNAMIC CHANGE

The following performances of a material with an external force applied can be used to transform the amount of dynamic change, that is, displacement, strain, pressure and vibration, into an electrical change.

(1) Strain gauge using a change in the electrical resistance of a resistance wire of semiconductive device, and to which an extraneous force is applied.

(2) Piezoelectrical element which is capable of producing an electrical output piezoelectric phenomenon upon the application of pressure to quartz crystal or barium titanate.

(3) Change in distance between two electrodes causing a change in electrostatic capacitance when an external force is applied to the substance.

(4) Change in the magnetic properties of a ferromagnetic substance caused by a strain.

(5) Change in the electromagnetic characteristics of a substance caused by a change in displacement.

There are many other types of transducers. Normally these transducers are attached to or placed on a substance under measurement.

The abovementioned transducers are used for particular applications depending upon their characteristics, for example, some transducers are used for strain measurements, some for pressure measurements and some for vibration measurements.

They are also classified into several categories according to operating conditions, which include high temperature types, high humidity type, high frequency type, large signal type, small signal type, etc.

In addition, there are other types of transducers under development, which show promising for future applications.

MEASUREMENT OF LIGHT AND TEMPERATURE

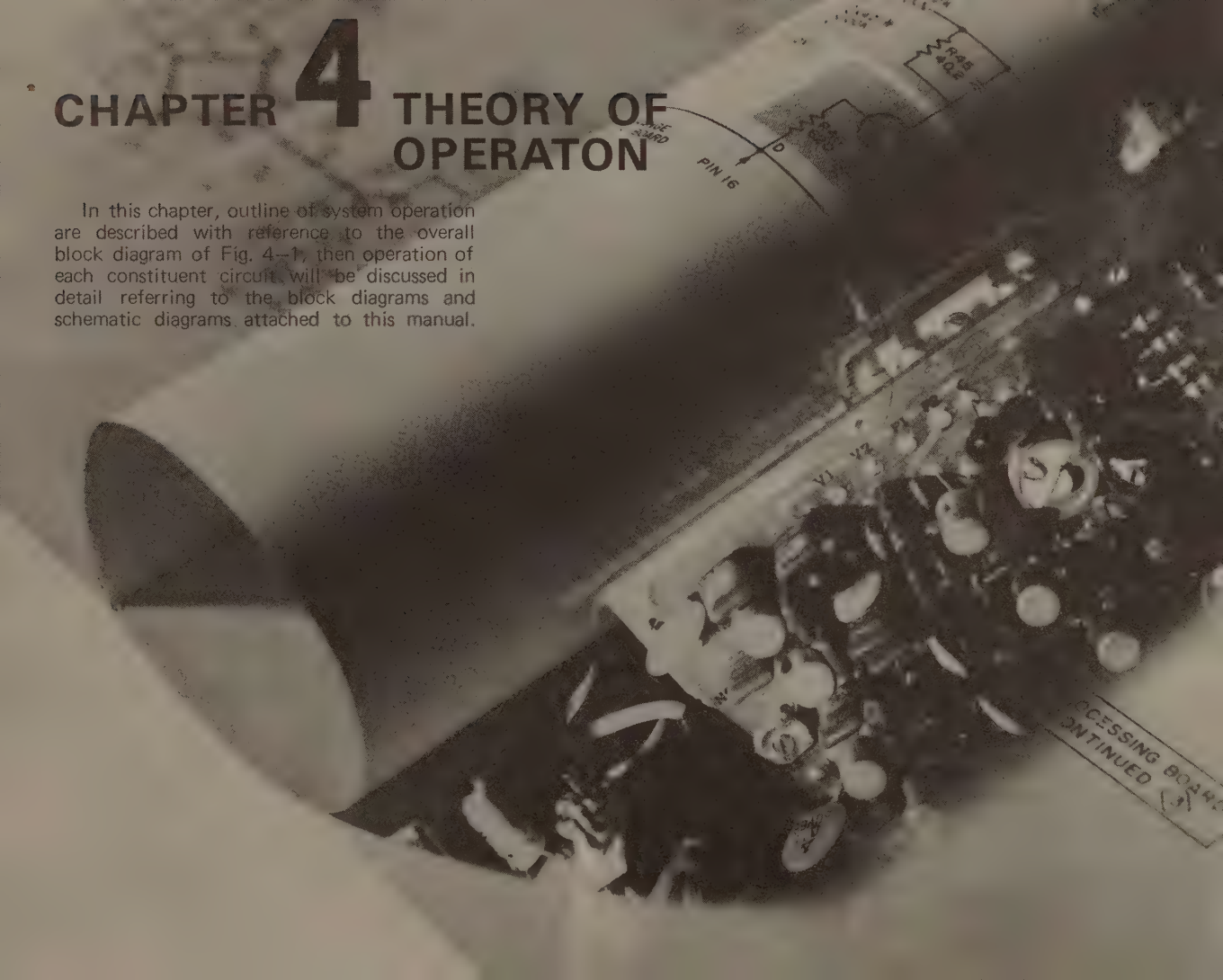
Devices such as phototubes, phototransistors, etc., which convert light energy into electric energy, are available; and photomultiplier tubes which detect a very feeble light are also available.

Devices which measure temperature include a thermistor, which utilizes the linear relationship between the variations in electrical resistance and temperature of a semiconductor and a thermocouple which utilizes the phenomenon that a proportional electromotive force (e.f.m.) is produced as a result the temperature at the junction of two dissimilar metal wires such as copper and constantan.

MEMO

CHAPTER 4 THEORY OF OPERATON

In this chapter, outline of system operation are described with reference to the overall block diagram of Fig. 4–1, then operation of each constituent circuit will be discussed in detail referring to the block diagrams and schematic diagrams attached to this manual.



OUTLINE

Circuitries shown in the block diagram of Fig. 4–1 finally serve the CRT to deflect the electron beam.

In the vertical deflection system, two independent preamplifiers are used. Operation of these preamplifiers can be optionally selected by means of electronic switching.

The input signal applied to the INPUT connector is converted through the preamplifier into a balanced signal and amplified. Output of this stage is fed into a delay cable driving amplifier. Selection of output from this stage is accomplished by means of a diode gate circuit in the delay cable driving amplifier to make a choice of any one of the following signals.

(1) Either of the independent outputs from CH 1 or CH 2 (CH 1 or CH 2)
(2) Sum or difference of signals from both channels (ADDED)
(3) Electronically-switched output from both channels (ALTER or CHOP)

Thus the selected output is fed into the delay cable.

In the delay cable line, a delay of approximately 120 nsec is provided to pass therein. The delayed output is then applied to the final amplifier, where it is amplified, and coupled to the vertical deflecting plate of the CRT, thus deflecting the electron beam in the vertical direction.

Meanwhile, a part of the input signal applied to the CH 2 is separated therefrom and amplified by a trigger amplifier.

Output from this amplifier is used as a trigger signal for the INT CH 2 ONLY mode of operation. Also, a part of the input signal is separated from the delay cable driving amplifier and used as a common trigger signal for CH 1 and CH 2. This trigger signal is used for the INT NORM mode of operation.

Depending upon the position of the SOURCE switch, any one of the abovementioned trigger signals or an external trigger signal applied through the TRIG OR HORIZ IN connector is coupled to the trigger circuit. The trigger circuit provides a trigger pulse having a particular rise time and amplitude upon receipt of a trigger pulse. The trigger pulse is used to drive a sweep generator to produce a sawtooth wave signal. This sweep generator is also used for a free-run type oscillation.

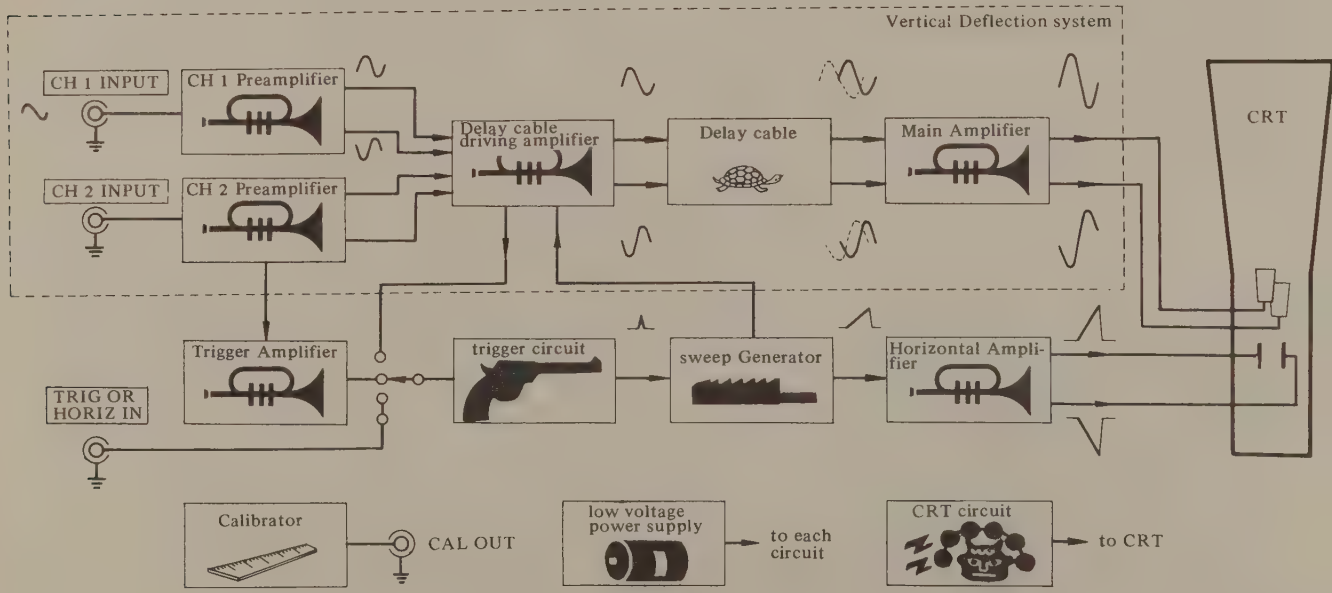
The sawtooth wave signal is amplified by a horizontal amplifier and applied to the horizontal deflecting plate of the CRT to deflect the electron beam in the horizontal direction, thus providing a sweep.

On the other hand, for an external sweep type operation, an extraneous signal applied to the TRIG OR HORIZ IN connector is coupled through a part of the trigger circuit to the horizontal amplifier. Output from this amplifier is used to deflect the electron beam similarly to the prescribed sawtooth wave signal. A calibrator functions to produce a reference square-wave signal to check the vertical deflection sensitivity of the instrument.

A low-voltage power supply provides low voltages to operate the circuits of Fig. 4–1.

A CRT circuit contains a high-voltage power supply used for emitting an electron beam and sweeping at high-speed and a Z-axis amplifier functioning to amplify an unblanking signal (used to blank fly-back line of the sweep) up to a level required to blank the fly-back line.

Fig. 4–1


Vertical Deflection system
CH 1 INPUT
CH 1 Preamplifier
CH 2 INPUT
CH 2 Preamplifier
Delay cable driving amplifier
Delay cable
Main Amplifier
CRT
Trigger Amplifier
TRIG OR HORIZ IN
trigger circuit
sweep Generator
Horizontal Amplifier
Calibrator
CAL OUT
low voltage power supply
to each circuit
CRT circuit
to CRT

VERTICAL DEFLECTION SYSTEM

The vertical deflection system consists of the circuits shown in Fig. 4–2. An input signal applied to the INPUT connector is fed through the AC-GND-DC switch to an attenuator. The attenuator is used to switch the deflecting sensitivity of the vertical deflection system and consists of an 11-range, phase-compensated, attenuation network. In the maximum sensitivity position, the attenuation is zero. As the sensitivity step goes on, the attenuation will increase to 1/2, 1/4 ..... .

Regardless of the attenuator position, the input resistance viewed from the INPUT connector is always 1 MΩ. Output from the attenuator is coupled to an input source follower (TR101A) using a junction type field effect transistor which is a counterpart of a cathode follower of an electron tube. It provides a high input impedance and low output impedance. The input source follower contains a D109 · 110 stage which functions to prevent the TR101A from damage caused by excessive input voltage applied to the INPUT connector. It also contains TR102A functioning to maintain balance of the following input preamplifier. A twin FET is used for this purpose to prevent the preamplifier from being unbalanced by change in temperature. DC BAL is a potentiometer used to set the preamplifier circuit for a proper balancing status. Since the input source follower cannot provide a low output resistance required for the following input preamplifier for its proper operation, an emitter follower is connected thereto to further decrease the output resistance.

Output from the emitter follower is fed into the input preamplifier, which is an emitter-coupled type symmetric amplifier (push-pull amplifier) and provides amplified output having a polarity opposite to each other, that is, a balanced signal (symmetrical waveform) on the collectors of TR106A and TR107A. The VARIABLE control is used to continuously vary resistance between emitters of TR106A and TR107A, thus adjusting the gain. Whereas, the POSITION control is used to change potentials applied to TR108A, TR109A and the following devices to control the vertical position of electron beam. This balanced signal is fed into a buffer emitter follower which is used to minimize mutual affection between the input preamplifier and delay cable driving amplifier.

The balanced output from the buffer emitter follower is coupled to the intermediate amplifier. In this amplifier, the GAIN ADJ control is used to vary resistance between emitters to control the amplifier gain and calibrate the deflecting sensitivity. For CH 2, the output from the intermediate amplifier is switched by the CH 2 POLARITY switch to reverse the polarity of the waveform displayed on the CRT screen.

On the other hand, an input signal applied to CH 2 is coupled through the input source follower to the emitter follower. At the same time, this signal is also fed into the trigger amplifier as a trigger signal for the CH 2 ONLY mode of operation.

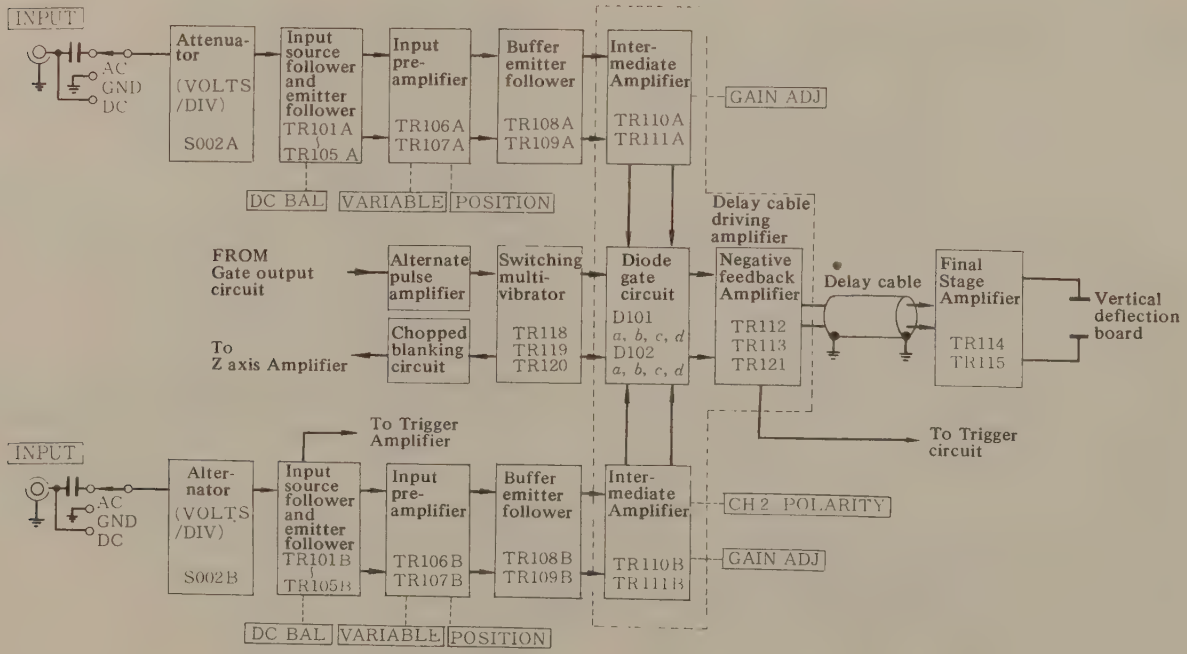
Next, output from the intermediate amplifier is applied to the diode gate circuit (Refer to Fig. 4–3). In the diode gate circuit, a dual trace operation is provided by means of diode switching. When the CH 1 only operates, the diodes function as follows.

D101 a, b	turned on
D101 c, d	turned off
D102 a, b	turned off
D102 c, d	turned on

Thus, the balanced output from the intermediate amplifier is fed into a feedback amplifier.

The on-off operation with these diodes is accomplished

Fig. 4–2 Block diagram of vertical defrection system



in the following manner. Since either CH 1 or CH 2 is always in operation, voltages at points (a) and (b) are constant voltage of approximately +1V. (Except for the ADDED mode, which will be described later.) In order to turn the D101 c, d off, voltage at point (c) will become approximately −1V or lower because of application of a voltage from the switching multivibrator. In order to turn the D102 a, b off, voltage at point (d) will be approximately +2V or lower. That is, as the anode voltage of D102 a, b is approximately +1V, turning the D102 c, d on and setting the cathode voltage of D102 a, b to approximately +2V will cause D102 a, b to turn off.

Next, in order to operate CH 2, the switching multivibrator is reversed by the MODE switch, thus inverting voltages at points (c) (d) referred to CH 1 operation.

For the ALTER mode of operation, as seen from Fig. 4−2, a signal from the alternate pulse amplifier (a pulse signal repetition rate is determined from the sweep time) is applied to the switching multivibrator the output of which is used to alternately switch the voltages at points (c) and (d). Therefore, it is possible to provide an alternate sweep of CH 1 and CH 2 signals at each end of the sweep.

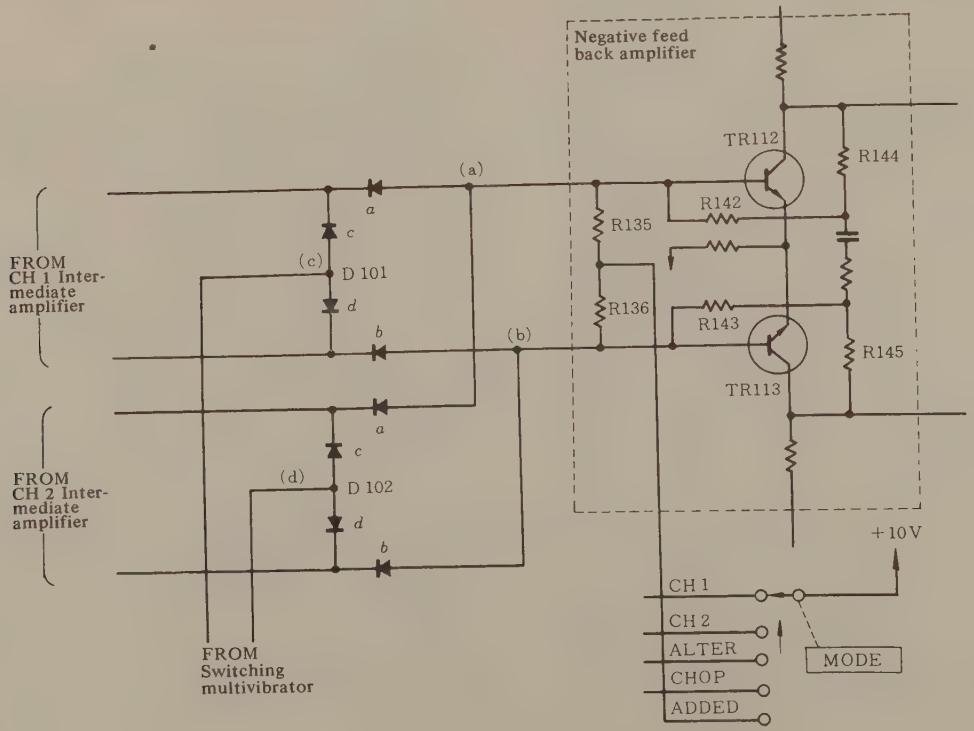
Since the switching multivibrator repeatedly operates for a free run oscillation at approximately 200 kHz in the CHOP mode of operation, the output pulse therefrom can be used to vary voltages at points (c) and (d) for accomplishing a switched sweep.

In the ADDED mode, when the MODE switch is turned to ADDED, the operating voltage of the switching multivibrator at that time, that is, voltages at points (c) and (d) will become approximately −1V. Hence, D101 c, d and D102 c, d will turn off, whereas, D101 a, b and D102 a, b will turn on, thus providing simultaneous operation of CH 1 and CH 2. In this case, since current increases to twice that for independent CH 1 or CH 2 operation, the current will flow through R135 and R136 so as to prevent the operating point of a negative feedback amplifier from being varied.

In this way, the balanced signal on CH 1 and CH 2 can be coupled to the negative feedback amplifier by using the MODE switch. The intermediate amplifier, diode gate circuit and negative feedback amplifier form a circuit called the delay cable driving amplifier. The intermediate amplifier and negative feedback amplifier operate in a current amplification mode, that is, presence of stray capacitance caused by particular elements which are related to the diode gate circuit and inserted between the balanced signals from the intermediate amplifier and negative feedback amplifier cause deterioration in frequency response at high impedances. Also since a 93 Ω delay cable is installed between the negative feedback amplifier and the final amplifier, it is necessary to lower input impedances of the negative feedback amplifier and final amplifier. Resistors R142, R143, R144 and R145 of the negative feedback amplifier (Refer to Fig. 4−3) are used for providing negative feedback circuits to realize such low impedance. Therefore, voltage levels of the output signal from those amplifiers are remarkably low, and the amplification of a signal up to the input of the final amplifier is regarded to be done in the current mode.

Output from this negative feedback amplifier is fed into a delay cable in which a time delay of approximately 120 nanosecond is provided. The balanced signal from the delay cable is amplified by the final amplifier and fed as a voltage signal to the vertical deflection plate of the CRT, thus deflecting the electron beam in a vertical direction. Meanwhile, the output signal from the negative feedback amplifier is coupled to the trigger circuit as a common trigger for CH 1 and CH 2 as well as applied to the delay cable as prescribed.

Fig. 4–3 Diode gate circuit



TRIGGER CIRCUIT

The trigger circuit consists of the circuits shown in Fig. 4–4. A part of the input signal applied to the CH 2 INPUT is coupled through the input source follower to the trigger amplifier. The signal is amplified in the trigger amplifier and used as a trigger signal for the INT CH 2 ONLY mode of operation. AC-coupled output connection is used for the trigger amplifier.

The SOURCE switch is used to select any one of the common trigger signals of CH 1 and CH 2, trigger signal for the INT CH 2 ONLY or an external trigger signal. The selected trigger signal is fed into the input source follower through a particular coupling path selected by the COUPLING switch. Namely, in the AC position, the DC component of the trigger signal is rejected by a capacitor connected in series, and only signals of frequency of approximately 50 Hz or higher are allowed to pass.

In the LF REJ position, low-frequency noise superimposed on the trigger signal or low-frequency trigger signals of frequencies of approximately 30 kHz or lower are rejected by a high-pass filter, and only high-frequency trigger signals are allowed to pass. In the HF REJ position, a low-pass filter is used to cut out high frequency noises

Fig. 4–4 Block diagram of trigger circuit

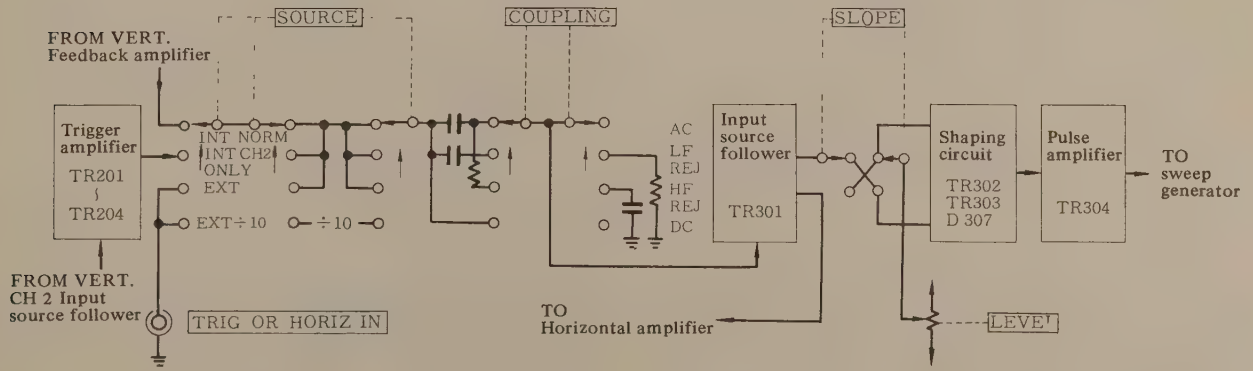
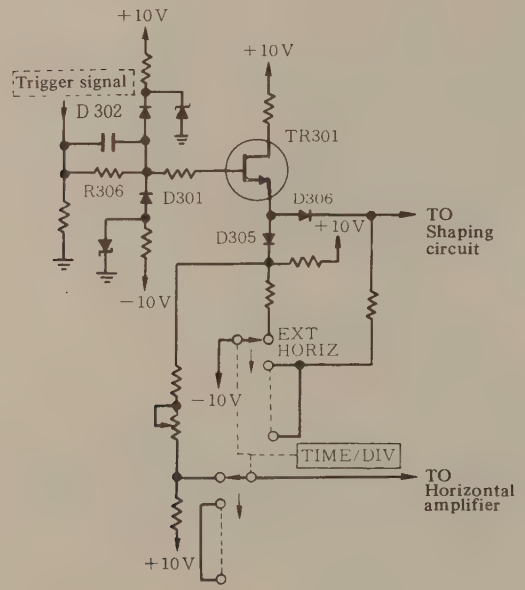


Fig. 4–5 Input source follower



superimposed on the trigger signal and high-frequency (approximately 10 kHz or higher) trigger signals, thus permitting only low-frequency trigger signals to pass.

In the DC position, the input trigger signals are directly coupled to the trigger circuit.

The input source follower uses an FET and provides a high input impedance and low output impedance.

As seen from Fig. 4–5, this source follower incorporates a limiter (D301, D302) to prevent the FET (TR301) from excessive voltage applied thereto. Normally, D301 and D302 are reverse-biased. When the input trigger voltage to this stage exceeds ±4V, the circuit will become conductive, thus limiting the amplitude by voltage drop in R306 (470 k Ω).

The signal path from the TRIG OR HORIZ IN connector to the source follower is also commonly used as the input circuit for an input signal in the external sweep mode of operation. (In this case, however, neither LF REJ nor HF REJ of the COUPLING selector can be applied.) For an external sweep, the TIME/DIV switch is set to EXT HORIZ and diode D305 is turned on, D306 is turned off, thereby, the input signal can be fed into the horizontal amplifier.

Operations other than the external sweep are done in the reverse order, and the trigger signal is coupled to the waveform shaping circuit.

The waveform shaping circuit consists of transistors TR302, TR303 and tunnel diode D307 as shown in Fig. 4–6.

Emitters of TR302 and TR303 are coupled to each other and fourther connected to a −10V supply through R321. This causes the circuit to provide a current mode switching --- one side turned on and the other side turned off. For example, the base voltage of TR302 is more positive in comparison with the base voltage of TR303, the transistors TR302 will turn on and TR303 will turn

off.

When the SLOPE switch is set to +, the trigger signal from the input source follower is applied to the base of TR303 and variable voltage controlled from the LEVEL control is applied to the base of TR302. As shown in Fig. 4–7, supposing that a sine wave trigger signal is applied to TR303 and a variable voltage E_L varied by the LEVEL control is coupled to base of TR302, TR302 will turn on and TR303 will turn off at the zero time point. When the sine wave increases in amplitude from zero to more than $+E_L$, and slightly exceeds the $+E_L$ level at time position t_1, TR303 will turn on and TR302 will turn off.

Fig. 4–6 Shaping circuit and pulse amplifier

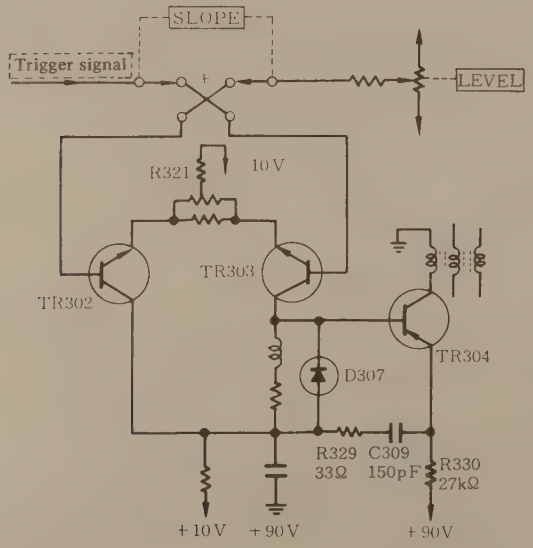
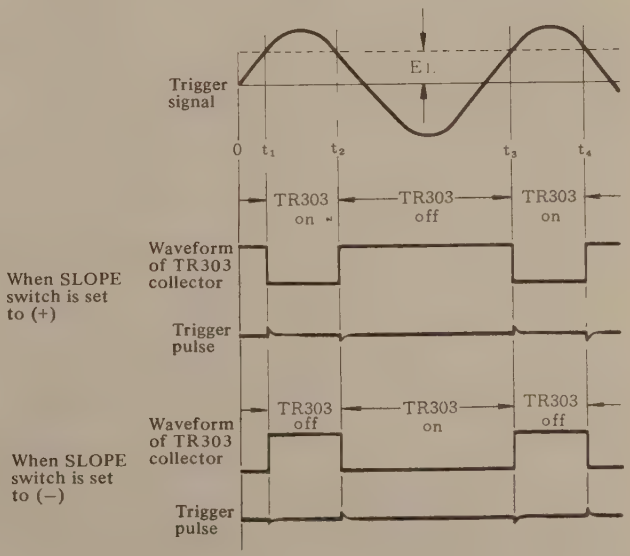


Fig. 4–7 Trigger signal and trigger pulse in time relationship



Whereas, when the sine wave has passed the peak and descends to the $+E_L$ level at time position t_2, TR303 will turn off and TR302 will turn on, thus returning to the original status.

As tunnel diode D307 is connected in series to TR303, it operates in the low voltage region of the tunnel diode characteristic of Fig. 4–8 when transistor TR303 is cut off. In this case, since a high resistance R330 is connected to the emitter of TR304 and said emitter is isolated from D307 by C309, current flowing in the transistor is very low.

If TR303 turns from off to on, a current exceeding Ip will flow in D307, causing this diode to jump into the high voltage region in a very short time. Thus, base voltage of TR304 abruptly moves to negative and current will flow abruptly through C309 and R329, thereby, a pulse transformer connected in series to the collector is driven and a positive-going pulse of a narrow width determined by values of C309 and R329 will be produced on the collector.

Next, when TR303 goes off, current flowing in the tunnel diode 307 will decrease to less than Iv and the diode operation is switched to the low voltage region in a very short time, thus returning to its original status.

At this time, a negative-going pulse is produced on the collector of TR304.

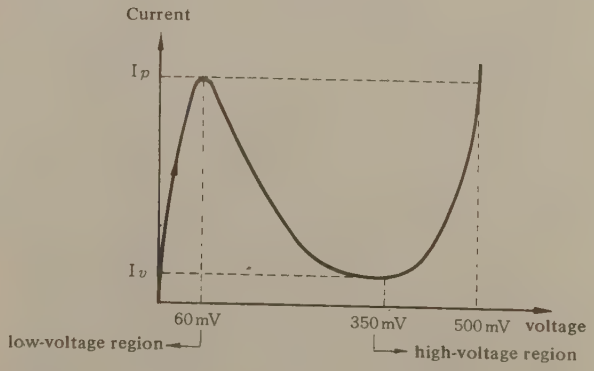
In this way, either positive and negative pulse is produced on collector of TR304 depending upon "on and off" status of TR303. To trigger the following sweep generator, the positive pulse is used. (This is referred to as trigger pulse.)

The trigger pulse (positive pulse) is produced when TR303 turns from off to on in Fig. 4–7, that is, t_1, t_3, ..., therefore, trigger pulse is generated in an arbitrary position of positive-going slope of the trigger signal which is under control of the LEVEL control. This means that the sweep can start at any position on the positive-going slope of the input signal.

Next, when the SLOPE switch is set to –, the trigger signal is applied to the base of TR302, and a variable voltage E_L varied by the LEVEL control is coupled to base of TR303 through the LEVEL control. In this case, TR302 starts to operate from its off status, as seen from Fig. 4–7 "when the SLOPE switch is set to –," hence TR302 will tune off and TR303 will tune on at the time of zero. Therefore, in opposition to the "when the SLOPE switch is set to +" status, TR303 will tune off from t_1 to t_2, will tune on from t_2 to t_3 and will tune off from t_3 to t_4. In this case, collector output wave from of TR303 will become opposite to that "when the SLOPE switch is set to +". The trigger pulse is generated at t_2, t_4 ..... .

In this way, the trigger pulses are generated and used to drive the sweep generator.

Fig. 4–8



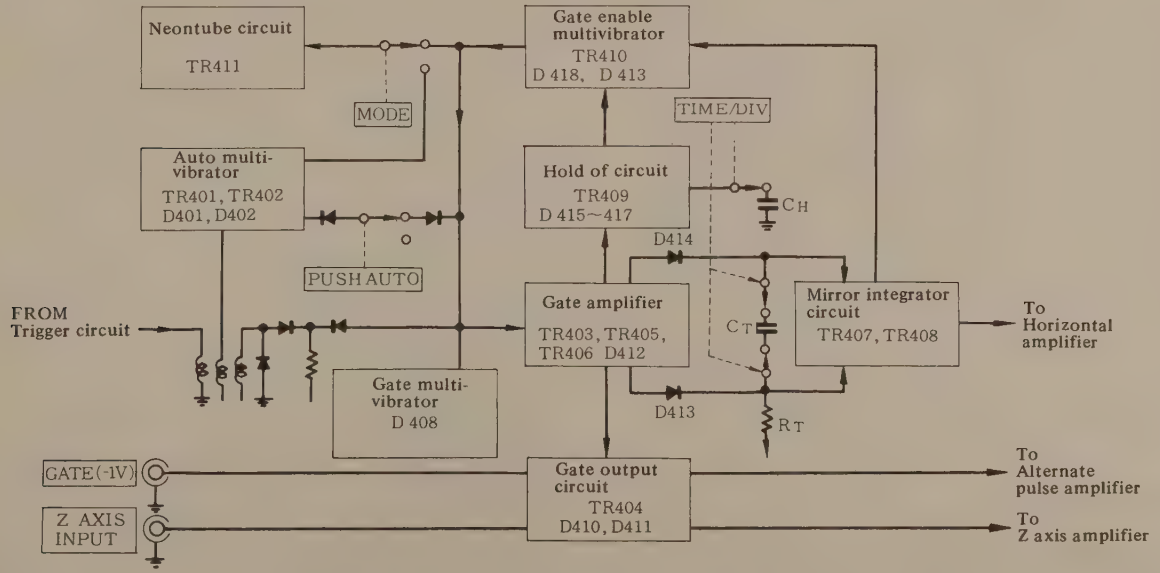
SWEEP GENERATOR

OUTLINE

The sweep generator provides the triggered sweep, automatic sweep and single sweep functions, and produces the following four signals.

(1) Positive sawtooth wave:
This signal is applied to the horizontal amplifier where it is amplified and used to provide a horizontal deflection of electron beam.
(2) Unblanking signal used to brighten the sweep
(3) Gate output to become negative only during slope (rising) period of the sawtooth wave

Fig. 4–9 Block diagram of sweep generator



(4) Alternate switching pulse generated at end of each sweep

Outline of the operation is as follows: (Refer to Fig. 4–9.)

A gate multivibrator is used to turn on and off the entrance of the miller integrator circuit (disconnecting diode D413). The gate multivibrator is normally in the off status and turns the diode D413 on through the gate amplifier.

When the gate multivibrator is inverted upon receipt of a trigger pulse, D413 is turned off and the miller integrator circuit begins to provide a linear increase in voltage (with a slope determined by a time constant of C_T and R_T of the TIME/DIV setting). When the increase in voltage reaches a predetermined level, the gate enable multivibrator turns on and the gate multivibrator is inverted, thus turning the diode D413 on through the gate amplifier. When D413 turns on, C_T and R_T begin discharging and the voltage will rapidly decrease. When the decrease in voltage has finished and a time preset by the C_H of TIME/DIV setting has elapsed, the gate enable multivibrator is turned off and the gate multivibrator is also returned to its original off status, thus completing a cycle to produce a saw tooth wave.

This is the operation of the sweep generator outlined in connection with the block diagram. Operations of the triggered sweep, automatic sweep and single sweep will now be described in more detail. Refer to the attached schematic diagrams of the trigger and sweep generator.

TRIGGERED SWEEP

Firstly, operation of the circuit under the steady condition (no trigger pulse being applied and no sweep being displayed) will be described. The circuit will go into the steady status upon setting of the MODE switch on the top panel to NORM then pulling and turning the (PUSH AUTO) LEVEL switch up to its extremely clockwise or counterclockwise position. Under the steady status, the circuit operates as follows:

Assuming that TR410 is turned off, level of current flowing in the tunnel diode D408 is lower than Ip (close to Ip) and this diode operates in the low voltage region. (Refer to Fig. 4–8.) TR403 is now turned off. In this case, emitter voltage of TR404 is approximately +1V, and D410 is in the off status, therefore, output voltage at the GATE connector will be zero volt.

Since base voltage of TR405 is fixed to approximately +3V, and TR403 is in the off status, emitter voltage of TR405 becomes higher than its base voltage and TR405 is turned on, thereby its collector voltage becomes positive. When the collector voltage of TR405 becomes positive, the disconnecting diode D413 is turned on, causing TR408 to become nearly "on" through the source follower TR407.

If, in this case, the sweep speed is lowered, resistance value for the TIME/DIV position becomes some 20 MΩ, then input resistance of TR407 must be very high. For this reason, a junction type FET is used as TR407 to increase input resistance of the miller integrator transistor TR408.

Because TR408 tends to turn on, collector voltage of TR408 tends to become nearly zero volt. However, this voltage is limited to approximately +2V by means of TR406 and D414 since the base voltage of TR405 is maintained at a fixed value of approximately +3V. Therefore, TR408 can not be turned completely on. As TR406 has a current flowing in the emitter and base, it turns on and the collector voltage will become approximately +2V.

Meanwhile, the hold-off capacitors C415 and C416 tend to be charged up to +10V through R444a, but D416 and D417 will turn on earlier, thus turning TR409 on. Hence, anode voltage of D415 can be held at approximately +1V and D415 is maintained in the off status.

Collector voltage of TR408 (anode voltage of D418) at this time is approximately +2V, however, D418 is held in the off status because cathode voltage of D418 is approximately +5.5V when TR409 is turned on. This voltage is used to supply a current to the tunnel diode D419 through R449. The current in D419 is set to Ip or lower with R450 and R451. TR410 is in the off status now, because D419 is in the off status now, because D419 is in the low voltage region. Our assumption that TR410 is in the off status has thus been proven as correct.

The operating status of the circuit will now be described. When a positive trigger pulse is applied through D406 to the sweep generator under the steady status, D407 will turn off and current flowing from D407 to R414 and R415, which is of approximately 3 mA, will flow into D408, thus increasing current in D408 by approximately 3 mA. This enables D408 to jump over Ip level up to the high voltage region, and the diode operation will become quite stable. Under this condition D408 will never return to its low voltage region even if a trigger pulse is applied thereto.

Then D408 has jumped to the high voltage region, TR403 will turn on and its collector voltage will decrease to approximately +1.5V. When the collector voltage of TR403 decreases, emitter voltage of TR404 becomes approximately −3V. Since D410 turns on at that time, a voltage of approximately −1.2V derived from a divider R427 − R428 will be developed at the GATE connector. After a complete cycle of operation, which will now be described, has finished, a gate signal (square wave) of approximately −1 Vp-p can be obtained.

On the other hand when TR403 is turned on, current flowing in TR405 through R419 and R429 will disappear and TR405 will be cut off. This causes collector voltage of TR405 to be switched to negative and D413 to be cut off. D412 will be turned on at this time and anode voltage of D413 is clamped at approximately −0.7V, thus preventing D413 from increase in leak current caused by excessively reverse biasing of D413.

When the disconnecting diode D413 is turned off, the timing capacitor C411 will be charged through R436 up to −75V. This charged voltage is applied through the source follower TR407 to base of the miller integrator transistor TR408. Hence, collector voltage of TR408 begins to increase in the positive direction. Because of a negative feedback loop from collector of TR408 to gate of TR407 through C411, the timing capacitor C411 can be charged from a constant-current type source, thus providing a good linear rising (rise in voltage) characteristic for the TR408 output. At the same time as the increase in collector voltage of TR408 which has resulted from turning off of TR405, TR406 and D414 will be cut off.

When TR406 is turned off, its collector voltage becomes −10V, and D415 and D416 are turned on and hold-off capacitors C415 and C416 are negatively charged. This causes D417 and TR409 to be cut off. Therefore, cathode voltage of D418 is switched from approximately +5.5V to approximately +10V. Even if, however, the cathode voltage of D418 becomes approximately +10V, the tunnel diode D419 can not be inverted.

While, since cathode-side voltage of D418 becomes approximately +10V, D418 can not be turned on until collector voltage of TR408 exceeds approximately +10V. When the TR408 collector voltage exceeds approximately +10V, D418 is turned on and current flows in D419 in

proportion to the increase in voltage. If the increase in collector voltage further continues, D419 will jump into the high voltage region. When D419 has jumped into the high voltage region, TR310 is turned on and current of approximately 5 mA flowing into D408 will be cut off, and D408 will return to its low voltage region. At this time, current in D408 is reduced to nearly zero, and the circuit can not be inverted even upon receipt of a trigger pulse.

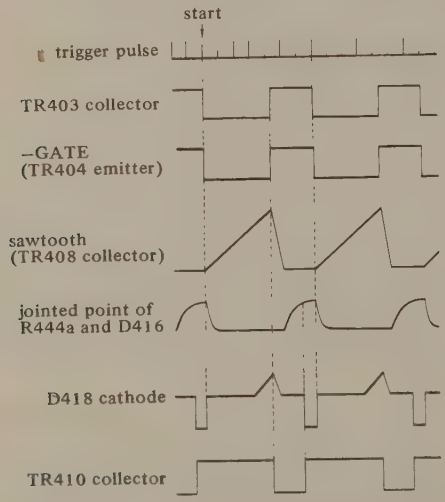
When D408 jumps into the low voltage region, TR403 is cut off and TR404 and TR405 will return to the steady status. Then, D413 will be turned on, and charges on C411 will rapidly be discharged through TR405 and D413. The collector voltage of TR408 will also rapidly decrease.

When the collector voltage of TR408 has completely decreased to a preset value of approximately +2V, D414 will become conductive, thus turning TR406 on. D418 will be cut off while the TR408 collector voltage is decreasing.

When TR406 is turned on, D415 and D416 are cut off, because C415 and C416 have been charged up to some −8V. Charges on C415 and C416 will then gradually be discharged through R444a. When the voltage across the capacitor decreases to nearly +1V, D415 and D416 will be turned on, as well as TR409 will also become conductive. Hence, cathode voltage of D418 is switched from approximately +10V to approximately +5.5V, thus causing D419 to return to its low voltage region and TR310 to be cut off. When TR310 is cut off, a current will flow into D408 through R456, thereby, the circuit will again go into a triggerable standby status.

A complete cycle of operation of the sweep generator has now finished, producing a sawtooth wave. This operation will continue repeatedly upon receipt of the successive trigger pulse. The sawtooth waveforms and waveforms at some important points of the circuit are shown in Fig. 4–10.

Fig. 4–10 Waveforms of sweep generator



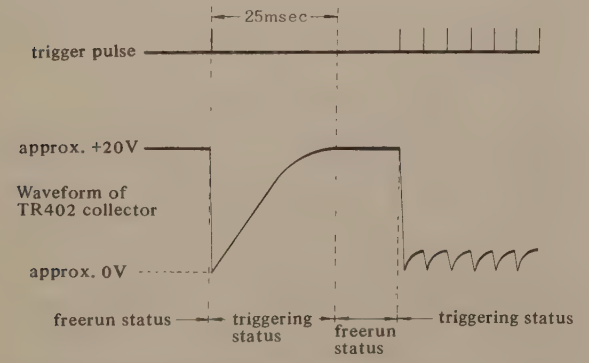
AUTOMATIC SWEEP OPERATION

The instrument operates in the automatic sweep mode when the (PUSH AUTO) LEVEL switch is pushed and other operational controls are set similarly to the triggered sweep mode of operation. The automatic sweep circuit (referred to hereafter as auto circuit) is a monostable

multivibrator consisting of TR401 and TR402 which is capable of discriminating the auto status or triggered status by detecting presence of a trigger pulse. Namely, if there is a trigger pulse detected, the circuit is switched automatically to the triggered sweep operation, whereas, the circuit is automatically switched to a free run mode of operation in the absence of trigger pulse.

Firstly, operation in the absence of trigger pulse will be described, Under this condition, a stable operation is provided with TR401 turned on and TR402 turned off. Therefore, C402 tends to be charged through R406 up to +90V. D403 is a 19V Zener diode which turns on at +19V. Current from R406 will flow through R410 and D404 to the tunnel diode D408. As prescribed in the "triggered sweep" section, current in D408 under a steady status does not exceed Ip but in this case, the current will

Fig. 4–11 Auto circuit operation



be higher, exceeding Ip. This is equivalent to the status in which D408 is always applied a trigger pulse. Then, the sawtooth wave will disappear and the circuit will return to the ready status. The sweep generator will, however, again operate to produce a sawtooth wave when the circuit has been reset as described above. This status is called a free run mode of operation.

Assuming now that a negative trigger pulse from T401 is applied to TR401, TR401 will be turned off and TR402 turned on, causing C402 to discharge through TR402. This causes D403 and D404 to be turned off, and D408 to be set for the ready status. In this way, the sweep generator has gone into the triggered sweep mode of operation. Since TR401 and TR402 form a monostable multivibrator, the circuit will return by itself to the original stable status with a time constant of R403, C401 and R404. When it returns, TR402 will be turned off and C402 will be slowly charged through R406. If the following trigger pulse will not be applied until the voltage across the capacitor being charged reaches +19V (in approx. 25 msec), D408 will be turned on, thus setting the sweep generator to its original free run status.

Assuming that the trigger pulses are applied at a repetition rate of 25 msec (40 Hz) or more, the trigger pulse functions to turn TR401 off and TR402 on before TR402 is turned off and C402 is charged up to+19V, D408 can not be turned on and the sweep generator will be maintained in the triggered sweep mode of operation.

SINGLE SWEEP

To provide a single sweep operation, set the MODE switch on the top panel to SINGLE and pull the (PUSH AUTO) LEVEL control. Set other switches in the same way as the prescribed triggered sweep mode of operation.

When the RESET switch is pushed to set the sweep generator to the ready status, only one sweep is triggered. No more sweep is displayed even if trigger pulses are applied. In this case, the circuit functions as follows.

At the end of a sawtooth waveform, as prescribed in the "Triggered Sweep" section, D416, D418 and TR409 will turn off and D419 is now in the high-voltage region. Discharge of C415 and C416 follows that, causing TR409 to turn on and D419 to step into the low-voltage region. TR410, then, will turn off and D408 will be in a ready status.

When the MODE switch is set to SINGLE, the base of TR409 is connected through R462 to a −10V supply, TR409 will stay in the cut off status even if D416 becomes conductive. This presents the return of D419 to its low-voltage region, and D408 cannot go into the "ready" status.

When the RESET switch is pushed, C418, which has been charged up to −10V, will be shortcircuited, thus, producing a positive pulse. This positive pulse is used to forcibly turn TR409 on and have D408 go into the ready status. Simultaneously, TR410 turns off and TR411 turns on, thus producing a potential difference across a neon tube NE401, which will then light to indicate a ready status for single-sweep, operation. When a trigger pulse is applied to the circuit under those conditions, as prescribed in the previous "Triggered Sweep" section, a cycle of generation of a sawtooth wave signal will begin. Upon completion of this cycle, the sweep generator is inactivated and provides a single sweep, because as prescribed, the device is coupled through R462 to a −10V supply. In this case, as TR410 is turned on and TR411 is turned off. The neon lamp will go off to indicate that the sweep has finished and the circuit is no longer in the ready status.

HORIZONTAL AMPLIFIER

Fig. 4−12 is a block diagram of the horizontal amplifier. As the input signal, one of the following signals is selectively applied to the horizontal amplifier in accordance with the setting. The signal is amplified to a level sufficient to deflect horizontally an electron beam in the CRT.

(1) Sawtooth wave signal supplied from the sweep generator
(2) External sweep (X−Y scope) input signal applied from the TRIG OR HORIZ IN connector through the input source follower of trigger circuit
(3) External sweep (X−Y scope) input signal from channel 2 INPUT connector

This signal is applied to the input amplifier. The input amplifier is a common-emitter type amplifier provided with an output-to-base negative feedback which improves the frequency response and stability. POSITION and FINE controls are used to vary base voltage on the input signal side of TR501, thus controlling horizontal position of the electron beam in the CRT.

Output from the input amplifier is fed into a differential amplifier. This differential amplifier is also called an emitter-coupled symmetrical amplifier. An amplified balanced signal consisting of two signal components whose polarities are opposite, are obtained at the collectors of TR503 and TR504. This differential amplifier is also provided with negative feedback to improve the frequency response and stability. The MAG switch provides a gain magnified 10, 20, or 50 times by switching emitter resistors of TR503 and TR504. (For external sweep, set the TIME/DIV switch to EXT HORIZ, then the gain is automatically magnified 20 times).

The SWEEP CAL is a screwdriver adjusted resistor used

to continuously vary the emitter resistance. The MAG CENTER is also a screwdriver adjusted resistor used to calibrate the display so it positions in the center of graticule.

Output from the differential amplifier (balanced signal) is amplitude-limited by D502 and D503, then fed into a buffer emitter follower. D504 and D505 are used to protect the amplifier and cut off, when a large signal is applied to the cathode side. The buffer emitter follower drives the final amplifier at low impedance.

The final amplifier functions to amplify the balanced signal up to a level at which the electron beam can provide sufficient deflection of the electron beam of the CRT.

Here, a part of the output from the normal signal is fed back to the buffer emitter follower, thus providing a negative feedback. This means that TR505 through TR508 function as operational amplifiers.

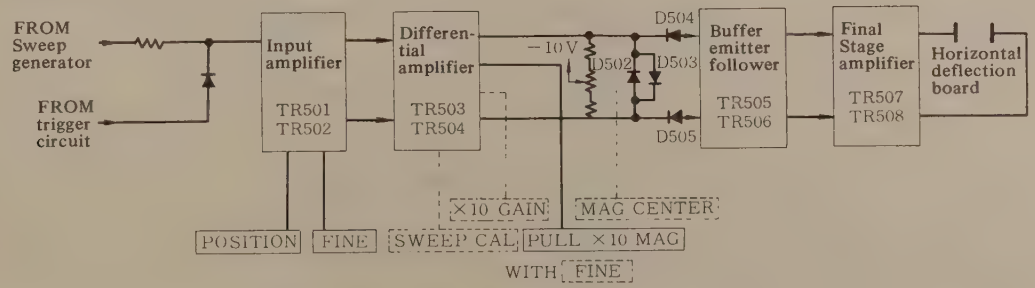
For this, the circuit operates stably to possible fluctuation in the power supply voltage, thus maintaining a constant average voltage on the horizontal deflection plate.

CRT CIRCUIT

HIGH-VOLTAGE POWER SUPPLY

Referring now to the accompanying CRT schematic diagram, the high-voltage power supply is derived from an oscillator which converts a low-voltage power supply output into a sine wave of approximately 30 kHz, the voltage of which is then amplified through a step-up transformer. Output from the transformer is then processed on the double voltage rectifying or half-wave rectifying basis. The oscillator consists of TR604 and TR601. TR603 is a shunt regulator used to control TR604. TR601 and TR602 are used as error amplifiers to control the high-voltage

Fig. 4–12 Block diagram of horizontal amplifier



power supply.

When the POWER switch is turned on, current will flow into the primary collector winding from the +15V supply. This causes the base winding on the same T601 to produce electromotive force, and base voltage of TR604 will become higher in the positive direction, and also the collector current thereof will tend to increase further. During this period, C602 will be charged to a negative potential level. The collector current will thus increase in this manner until it is saturated. When however, the current has reached a saturation point as to the collector current, the base winding will loose its electromotive force. Hence, the base voltage of TR604 will become negative because of the presence of C602. Thus TR604 will be cut off and collector current will decrease. The collector voltage will increase.

Now, an electromotive force will be produced in opposition to the previous operation. C602 will be charged to a positive potential level, C602 will gradually become conductive. This cycle is repeated and a 30 kHz signal is produced.

A stepped-up electromotive force is produced on the secondary side of T601. An electromotive force across terminals #5 and #7 is rectified by D602 and D603 on the double voltage basis and applied to the accelerating electrode (P3) of the CRT. While, an electromotive force developed across terminals #5 and #6 is rectified on the halfwave basis, then voltage-divided and coupled to the CRT grid. It is further divided and fed into the cathode through zener diodes D606 a, b. Meanwhile, in order to keep the secondary voltage constant at point G, a part of the secondary output is fed back to TR601. Variation in load detected by error amplifier is used to control TR603. The base current of TR604 is controlled from the emitter average level of TR603.

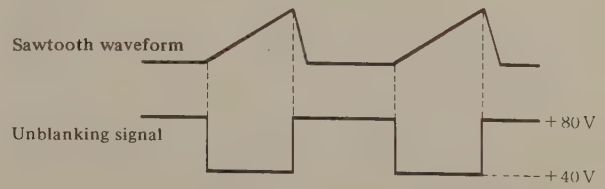
Z AXIS AMPLIFIER

Refer to the accompanying CRT CIRCUIT schematic diagram. The Z axis amplifier consists of a common-base type amplifier TR607 and emitter follower TR606. One of the following four signals is applied to the emitter of TR607 as set with the control.

(1) Unblanking signal used to erase return lines
(2) Chopped blanking signal used to eliminate transients in the CHOP mode of operation.
(3) Voltage upon pushing of the SPOT FINDER control
(4) Voltage required to display a spot in case of an external sweep D608 and D609 are diodes in the emitter circuit TR607 to provide amplitude-limited, linear amplification. Output from TR607 is fed into an emitter follower TR606 where the circuit impedance is lowered and the signal is coupled to the deflection blanking plate of the CRT.

One side of the deflection blanking plate is connected to

Fig. 4–13



D605 and applied a voltage of approximately +40V. The other side of the electrode is normally applied a voltage of approximately +80V. Upon receipt of the above-mentioned signals, this voltage will become approximately +40V, then a spot or trace will appear. For example, a trace such as seen in Fig. 4—13 will be displayed.

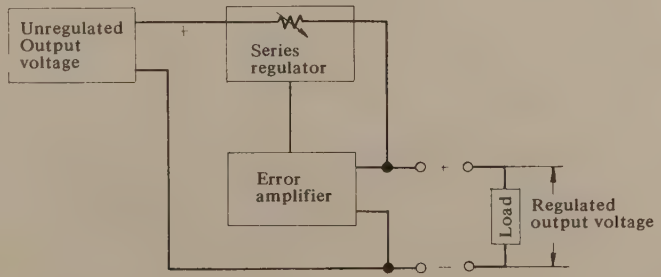
LOW VOLTAGE POWER SUPPLY

The low-voltage power supply contains a DC low-voltage source and a 6.3V AC voltage used to heat the CRT. The low-voltage supply provides —10, +10, —75 and +90V regulated DC voltages and +130V unregulated DC voltage.

The unregulated +130V is derived from AC mains supply through a power transformer, where the mains voltage is stepped up to 110V, and a diode bridge D801 a, b, c, d, and a filter thereby, the output voltage contains comparatively low ripples.

Fig. 4—14 shows a basic circuit diagram of the regulated power supply. The unregulated output voltage is applied to a load and a variable resistor connected thereto in series. The variable resistor controls the voltage across the load for a constant level. This function is accomplished by using an error amplifier which operates upon receipt of an error signal derived from the difference between the output and reference voltages in order to control the series regulator to maintain a constant output voltage. The regulated power supplies of this instrument also utilize the same principle. By way of an example, operation of the —75V regulated power supply will now be described, referring to the

Fig. 4—14 Basic circuit of Regulated Power Supply



attached POWER SUPPLY schematic diagram.

The 100V AC output from the T801 terminals #9 – #10 is rectified by a diode is rectified by a diode bridge of D802, a, b, c, d and smoothed by C808, C809, R813, R836, then the DC output is applied to TR805 and load. In this case, TR805 functions as a series regulator as prescribed. TR807 and TR808 form an error amplifier (comparing amplifier). The base of TR807 is connected to D807 (8.5V zener diode) and the base of TR808 is connected to a junction for dividing the output voltage. Changes in the output voltage are amplified by this error amplifier and the output therefrom is used to control the series regulator transistor TR805.

CALIBRATOR

Fig. 4–15 is a block diagram of the calibrator. (Refer to the attached schematic diagram of calibrator.)

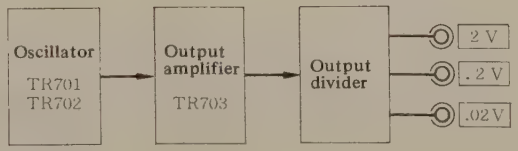
The oscillator consists of transistors TR701 and TR702. Oscillation is encountered through a feedback loop from a winding of T701 to the base of TR701. The oscillation frequency is 1 kHz, which is controlled by the collector-side winding of T701 and C703. Mutual compensation with these inductors and capacitors, each of which has a very low temperature coefficient, provides high temperature stability for the frequency drift. C702 also provides a feedback loop for re-oscillating with TR702 as well as the feedback loop to base of TR701.

This loop also functions to speed-up the oscillation through TR702. A square wave output is provided at the collector of TR702 and applied to the output amplifier transistor TR703.

Upon receipt of the application of the square wave signal to the base, TR703 is alternatively switched between a saturated status and cutoff status, thus producing a square wave voltage of approximately 0 to +10 volts at the collector.

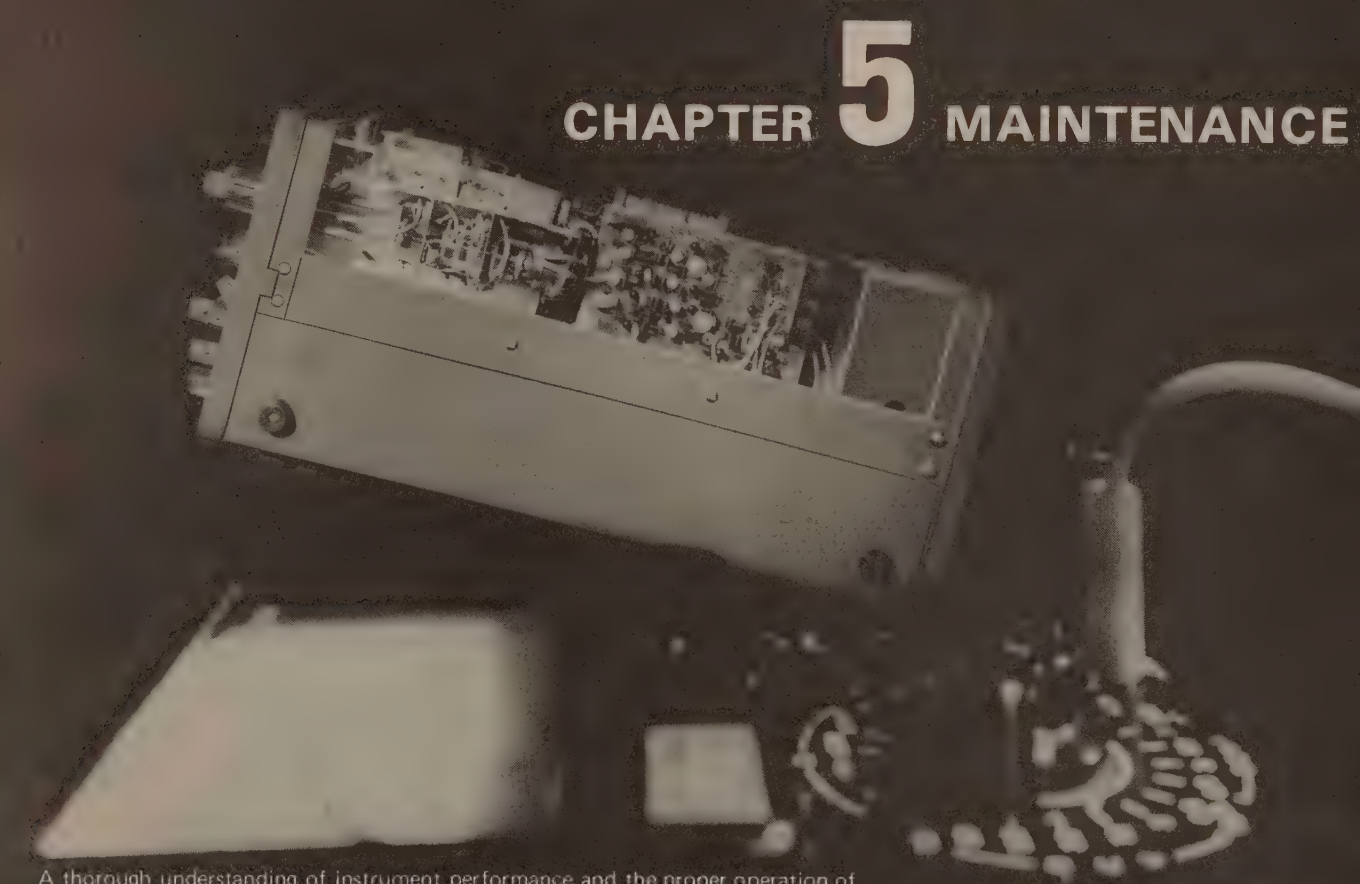
The output is divided by an output divider and coupled to the 2V, 0.2V and 0.02V output terminals, respectively.

Fig. 4–15 Block diagram of calibrator



MEMO

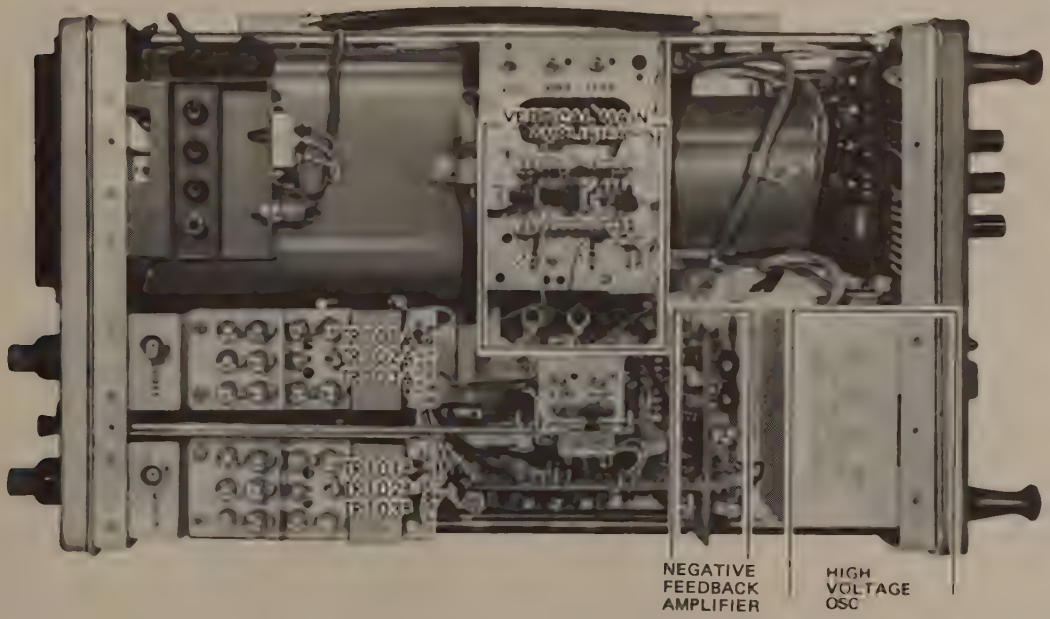
CHAPTER 5 MAINTENANCE



A thorough understanding of instrument performance and the proper operation of switches and controllers conforming to this manual (especially precautions described in item –Preliminary–), are essential for prolonged life of the instrument. Adequate care is also required when the instrument is not in use. The following points are precautions for maintenance and remedies for troubles.

Refer to the attached "Parts Layout on Printed Circuit Board" for checking and replacing circuit components.

Fig. 5–1



REMOVAL OF DIRT

When the front panel or covers become very dirty, wash them with neutral cleanser. Avoid using cleansers containing thinner or alcohol, to protect the paint. Remove the covers prior to washing them. To remove dust inside the instrument, use an air compressor.

MAINTENANCE OF INSTRUMENT NOT IN USE

If the instrument is not used periodically, remove the probes or adapters from the panel, and store in the accessory bag. Protect the instrument with the dust-proof cover, and store the instrument, preferrably, in a dry and well ventilated place.

TROUBLESHOOTING

ORDER OF TROUBLESHOOTING

The primary purpose of troubleshooting is find out if the irregularity is caused by the synchroscope or by external conditions. For example, if the AC line voltage is not within limits, or an external obstruction is induced in the INPUT connector, synchroscope operation may be faulty. If the synchroscope triggers horizontal sweep normally, but the displayed waveform is unusual, it will be difficult to judge whether or not the syncroscope is the cause. In such a case, an additional signal should be applied to the INPUT connector to see if a similar display occurs.

The procedure (order) of troubleshooting is described below:

(1) Before removing the cover in order to check the internal circuit operate the from-panel controllers and switches in order to locate the faulty circuit; Power supply? CH 1 or CH 2 preamplifier? Trigger generator? or Horizontal amplifier?

(2) Remove the cover, and visually check the parts and associated wiring in the suspected circuit. The various causes of trouble can be detected only by a visual check. For example, a burnt-resistor.

(3) Check voltages in the high and low voltage circuits (Refer to Chapter 6). The low voltage circuit largely influences the entire circuit operation. Any excess voltage in this circuit must be corrected.

(4) Use a circuit tester or another synchroscope to check the circuit operation, referring to the circuit diagram attached to the last page.

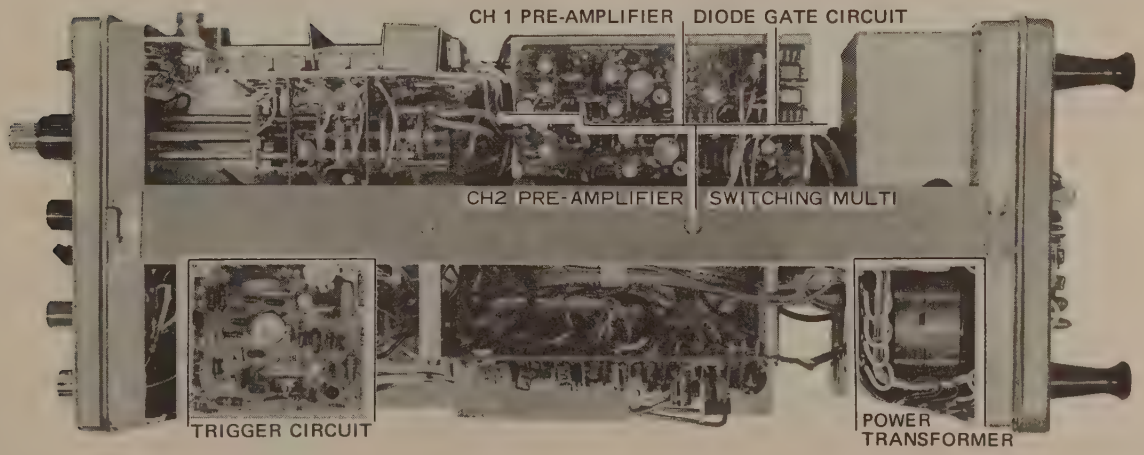
LOCALIZING TROUBLE ACCORDING TO SYMPTOMS

(1) WHEN NO SPOT APPEARS:

When no spot appears on the CRT screen the probable causes will as follows.

- o Either the high-voltage power supply and Z-axis amplifier is defective.
- o Malefunction in the vertical deflection system
- o Horizontal amplifier is defective.

Fig. 5–2


CH 1 PRE-AMPLIFIER
DIODE GATE CIRCUIT
CH2 PRE-AMPLIFIER
SWITCHING MULTI
TRIGGER CIRCUIT
POWER
TRANSFORMER

In this case, first, switch-over the operating channel. If a spot appears on either channel, the cause of the trouble must be in the preamplifier by which no spot will appear.

If the spot does not appear in either case short-circuit the vertical and horizontal outputs at side pins on the CRT and increase the brightness. If the spot does not appear yet, something must be defective in either the high-voltage power supply or the Z-axis amplifier.

If a spot appears when both the vertical and horizontal outputs are shortcircuited, try to short-circuit either of the two outputs, not at a time, to localize the trouble. The cause of trouble must be found in either the vertical or horizontal circuits, on which the spot appears when shortcircuited.

(2) SPOT APPEARS WITHOUT SWEEPING:

If the trace does not sweep, set the TIME/DIV to EXT HORIZ and turn the POSITION control (horizontal) in each direction. If the spot can move over full range of the screen and the normal amplitude as specified in Chapter 2 is obtained upon application of a calibrating voltage to the TRIG OR HORIZ IN connector, the horizontal amplifier is normal and the trouble is caused by the sweep generator.

(3) SWEEP APPEARS BUT NOT TRIGGERABLE:

In case the trace can be triggered from an external signal (at the specified voltage) but cannot be triggered internally in the INT NORM mode (at the specified amplitude), no trigger signal from negative feedback amplifier must be applied to the trigger circuit. If the trace cannot be triggered in the INT CH 2 ONLY mode of operation, the defect must be in the trigger amplifier. If the trace cannot be triggered from either the internal or external trigger signal, the trigger circuit is defective.

(4) VERTICAL AMPLITUDE IS NON-LINEAR:

In case the vertical amplitude is varied depending upon position of the trace when turning the POSITION (vertical) control, or the waveform distortion varies significantly depending upon vertical position of the trace, the probable cause is a defective transistor in the vertical deflection system.

(5) FAILURE IN DUAL TRACE OPERATION:

In the failure occurs only in the ALTER mode of the dual trace operation, check the alternate pulse amplifier for proper operation. If dual trace operation cannot be carried out in both the ALTER and CHOP modes, there must be a defect between the switching multivibrator and diode gate circuits.

(6) HORIZONTAL SWEEP IS NON-LINEAR:

In case the sweep time greatly varies depending upon horizontal position of a trace, the probable cause will be as follows:

First, if degree of the POSITION (horizontal) control, the horizontal amplifier must be defective. If the degree of non-linearity does not change in this case, the sweep generator (particularly the miller integrator) must be defective.

Fig. 5–3

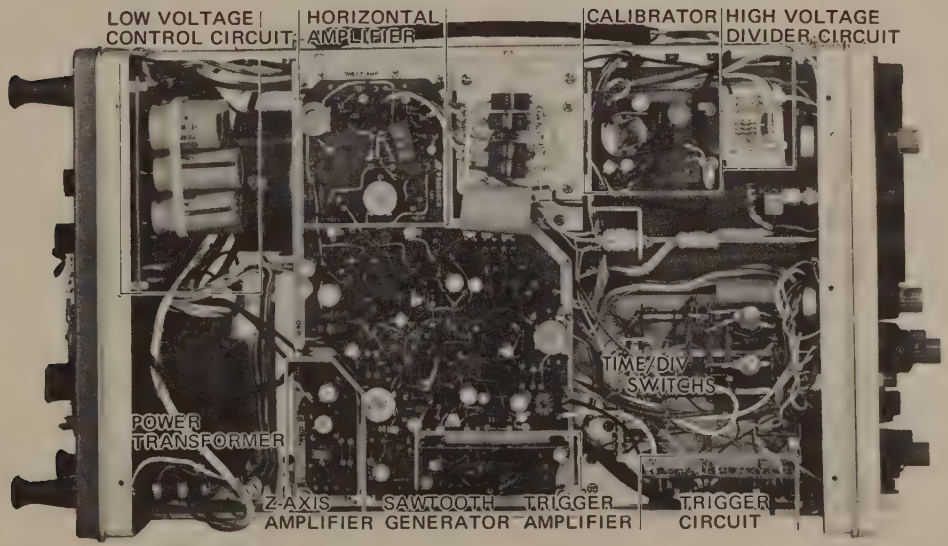
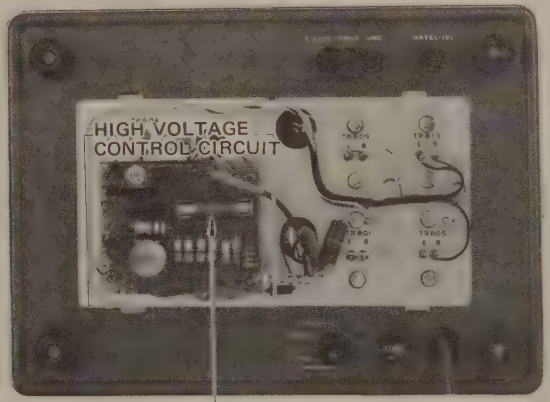

LOW VOLTAGE CONTROL CIRCUIT
HORIZONTAL AMPLIFIER
CALIBRATOR
HIGH VOLTAGE DIVIDER CIRCUIT
TIME/DIV SWITCHS
POWER TRANSFORMER
Z-AXIS AMPLIFIER
SAWTOOTH GENERATOR
TRIGGER AMPLIFIER
TRIGGER CIRCUIT

Fig. 5–4



REPLACEMENT OF PART

REMOVAL OF COVERS

To take off the top cover, remove four set screws in the corners of the top cover and lift it. For the bottom cover, remove the six screws. Also, take out the four screws to remove the rear cover.

REMOVAL OF PRINTED CIRCUIT BOARDS

Each of the printed circuit boards can be easily removed by removing the fastening screws and relevant interconnections.

The printed circuit boards of the horizontal deflection system can be lifted by removing the screws and part of the wiring as shown in Fig. 5–5.

Whenever interconnections, are disturbed, be sure to return them to their original positions. Failure to do so, may damage semiconductor devices or cause burnt resistors.

REPLACEMENT OF TRANSISTORS AND DIODES

Prior to replacement, make sure that the spare semiconductors are of good quality. Since these semiconductors are sensitive to temperature, they must be soldered as quickly as possible while holding their connecting leads (lead position close to the semi-conductor) using long-nose pliers or tweezors. Also be careful, when removing a defective part from a printed circuit board, that the copper foil does not peel.

REPLACEMENT OF RESISTORS AND CAPACITORS

Since only specially selected resistors and capacitors are used in the synchroscope, only quality parts may be used for replacement. Since most of the defects in parts, burnt resistor or short-circuit capacitor, etc., are subsequently caused by short-circuit of a vacuum tube or transistor electrodes, these defective parts should not be replaced until the trouble has been remedied.

CATHODE RAY TUBE REPLACEMENT

The Cathode Ray Tube is replaced in the following order:

(1) Remove the cover.
(2) Unsolder the rotation coil lead-wire at the circuit board side.
(3) Remove the deflection output pins from the CRT.
(4) Disconnect the CRT anode connector. Ground the anode connection to discharge any stoved charge.
(5) Remove the CRT socket.
(6) Remove the bezel, by removing the four screws.

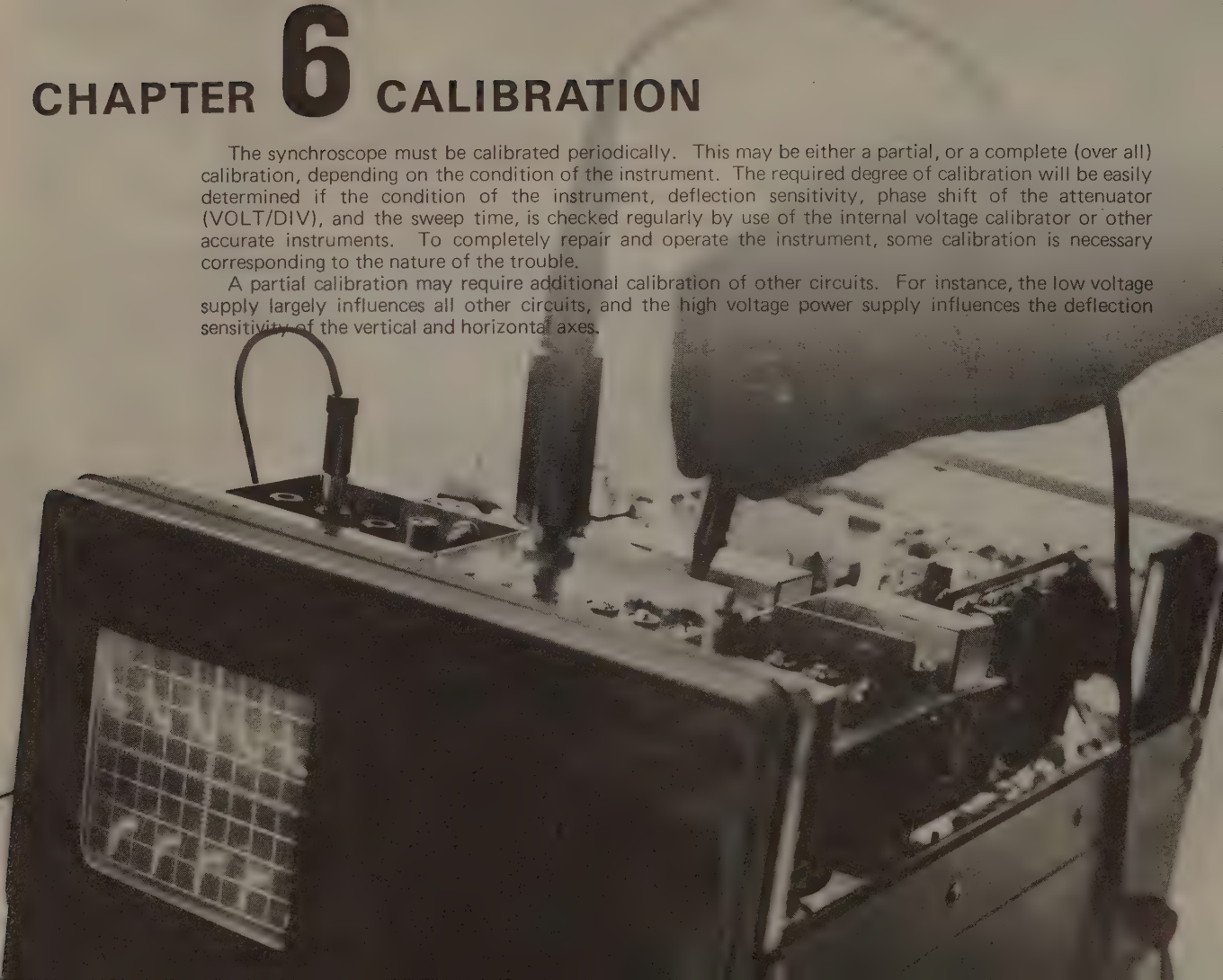
After these procedures are completed, push the CRT toward the front panel and remove the CRT.

The CRT can be inserted by reversing the above sequence make sure that the output deflection pins are connected according to their color codes.

CHAPTER 6 CALIBRATION

The synchroscope must be calibrated periodically. This may be either a partial, or a complete (over all) calibration, depending on the condition of the instrument. The required degree of calibration will be easily determined if the condition of the instrument, deflection sensitivity, phase shift of the attenuator (VOLT/DIV), and the sweep time, is checked regularly by use of the internal voltage calibrator or other accurate instruments. To completely repair and operate the instrument, some calibration is necessary corresponding to the nature of the trouble.

A partial calibration may require additional calibration of other circuits. For instance, the low voltage supply largely influences all other circuits, and the high voltage power supply influences the deflection sensitivity of the vertical and horizontal axes.



LOW VOLTAGE POWER SUPPLY

Prior to calibration, the low voltage power supply must be checked. Since the low voltage considerably influences each circuit, an accurate DC voltmeter (class 0.5 or of greater precision) must be used for the calibration.

Two types of circuits comprise the low voltage source: Regulated supply and non-regulated supply. They are listed in Table 6–1. Test points for these supplyes are shown in Fig. 6–1. Perform calibration in the order specified in Table 6–1, whenever degrees or error with voltages measured across the test points and ground are high. The location of these rheostats are shown in Fig. 6–1.

Table 6–1

Low voltage supplyes	Type	Color code of wire	Allowance	Ripple	Measuring condition	Order for calibration	Location for calibration
– 75V	Regulated	Violet	0%	200 V or less	Set the line voltage in 200V	1	R820 –75V ADJ
+ 90V	"	White-yellow	±1%	"	"	2	R811 +90V ADJ
– 10V	"	White-black	±1%	"	"	3	R834 –10V ADJ
+ 10V	"	White-red	±1%	"	"	4	R827 +10V ADJ
+130V	Un-regulated	White-orange	140 – 160V	5V or less	"	Confirmation	————

HIGH VOLTAGE POWER SUPPLY

Fluctuation of the high voltage causes a variation of both the vertical and horizontal deflection sensitivities. If the voltage varies excessively focusing and intensity of the CRT will be varied.

The high voltage which requires calibration is the cathode voltage of the CRT. Measure the high voltage at the test point shown in Fig. 6–6, and calibrate the voltage using R601 H.V. ADJ (Refer to Fig. 6–1).

INTENSITY

First, set the following controls.

Free run

TIME/DIV 0.2 μsec

INTENSITY Approximate mechanical midpoint

When the R638 INTEN ADJ control (Refer to Fig. 6–5) is turned clockwise, the trace will become brighter and at a certain point, you will see the spot and flyback line of the sweep. Set the INTEN ADJ control to a position just before this point. This is the proper status of the calibrated operation.

Fig. 6–1 Square waveform Response adj (Vertical amplifier)

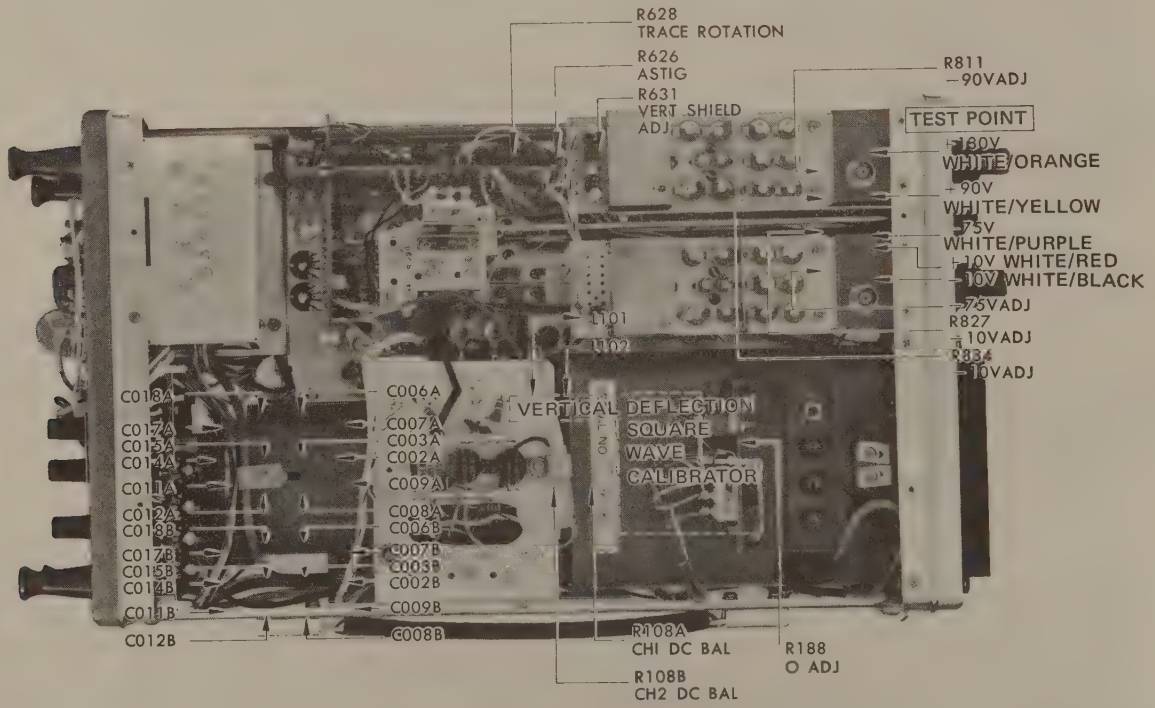
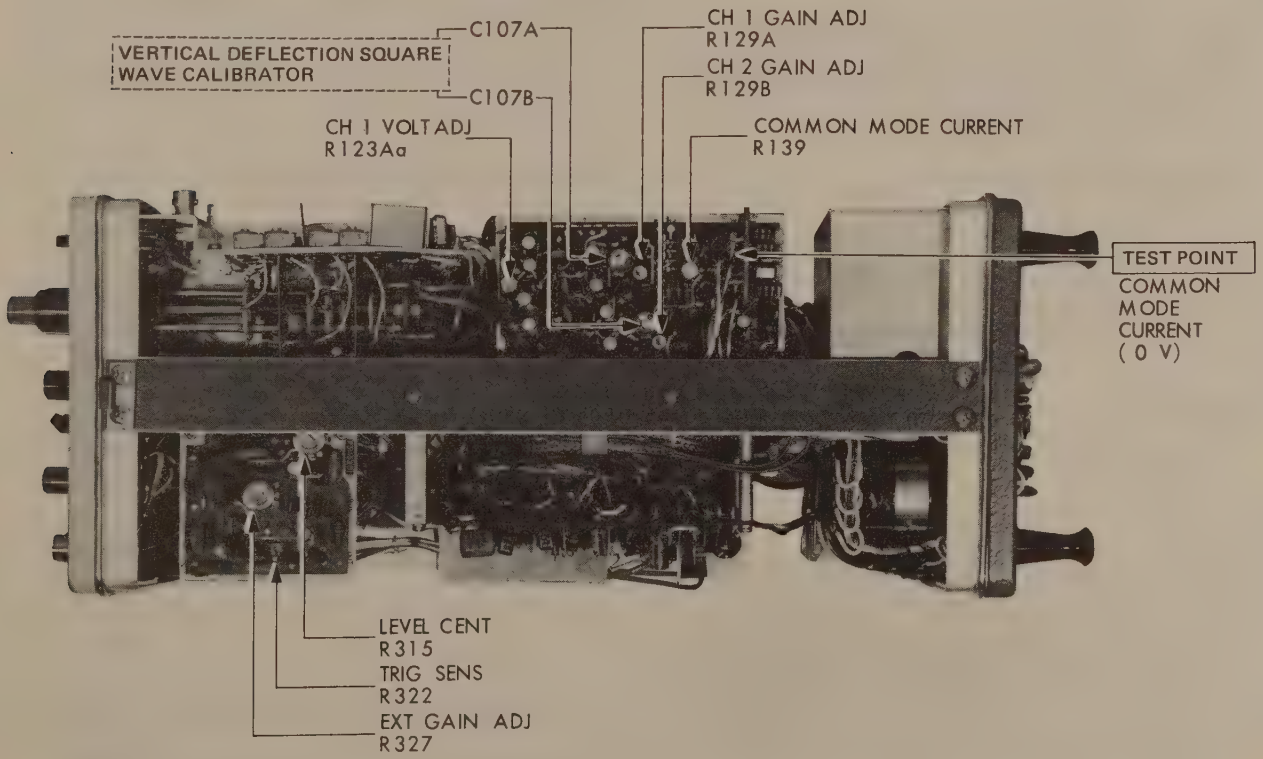


Fig. 6–2 Square waveform response adj (Vertical amplifier)



COINCIDENCE OF TRACE WITH GRATICULE

The coincidence of trace with the graticule, even it has being correctly adjusted, may be lost due to earth mangetism. They are coincided, by setting the trace to the center of the graticule, and adjusting R509 TRACE ROTATION (Refer to Fig. 6–1).

PATTERN DISTORTION

Adjust the calibration voltage waveform so it fills the graticule of the CRT screen and then adjust R631, VERT SHIELD ADJ, (see Fig. 6–1) to correct the waveform so it appears as shown in Fig. 6–3. Even after adjustment, some distortion inevitably remains due to CRT characteristics.

DC BALANCE

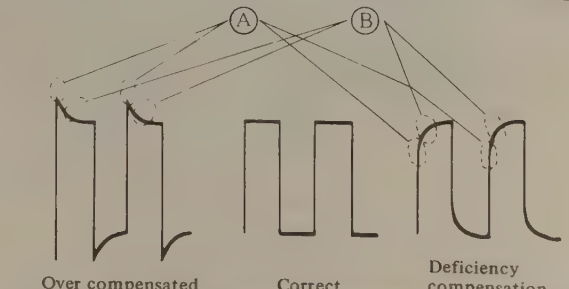
If the trace moves up or down when the VARIABLE control is turned, the DC balance of the vertical amplifier must be adjusted. Adjustment is accomplished in the following manner: First, place the AC-GND-DC switch in the GND position to move the sweep to the center of the CRT screen. Next, while rotating the VARIABLE control in either direction, adjust the DC BAL control so that the sweep will remain on the center of the CRT screen.

Fig. 6–3

VERTICAL DEFLECTION SENSITIVITY

Apply an input signal of 10 mV (1 kHz) from an accurate audio oscillator to the INPUT connector. Place the VARIABLE control in the CAL position and with the VOLTS/DIV switch set at the 5 mV range, adjust the GAIN ADJ control (see Fig. 6–2) so that the amplitude of the displayed signal is two divisions on the graticule. Next, confirm that the amplitude of the displayed signal is two divisions for each position of the VOLTS/DIV switch with an input voltage twice that indicated by the VOLTS/DIV switch. The accurancy of each range should be within ±3%

Fig. 6–4



of that indicated by the position of the VOLTS/DIV switch. If, however, it deviates beyond this, it signifies that the attenuation at that particular setting has varied.

PHASE OF VOLTS/DIV (ATTENUATOR)

When the phase of the VOLTS/DIV switch is not correctly calibrated, the displayed waveform will be distorted and frequency response characteristics will be impaired.

Provide a square-wave generator (with 0.1 μsec or less rise time characteristic) and connect a probe to the INPUT connector. Couple tip of the probe to output connector of the square-wave generator.

First, set the VOLTS/DIV to 5 mV and control output from the square-wave generator for 3 to 4 vertical divisions. Move the trace to center of the CRT screen. Try to trigger the sweep, referring to the "Probe Phase Calibration" paragraph on page 3–6, and complete the adjustments for obtaining the phases shown in Fig. 6–4. In this case, no Ⓐ portion is required for the adjustment.

Next, set the VOLTS/DIV to 10 mV, and vertical amplitude to 3 to 4 divisions. Then, calibrate the instrument for part Ⓐ by adjusting C007 A/B (Refer to Fig. 6–2, in which C007A is for CH 1 and C007B is for CH 2; the same will apply to the following descriptions).

Calibrate the Ⓑ portion by controlling C006A/B. For other ranges, perform the calibration in the order shown in Table 6–2.

Table 6–2

VOLTS/DIV range	Trimmer capacitor for calibration	
	For section A	For section B
5 mV	————	C005 A/B
10 mV	C007 A/B	C006 A/B
20 mV	C009 A/B	C008 A/B
50 mV	C012 A/B	C011 A/B
.1	C003 A/B	Automatically compensated
.2	C002 A/B	"
.5	C015 A/B	C014 A/B
1	Automatically compensated	Automatically compensated
2	"	"
5	C018 A/B	C017 A/B
10	Automatically compensated	Automatically compensated

COMMON MODE CURRENT AND CH 1 VOLT ADJ

If the balance of the negative-feedback amplifier is incorrect, the electronically switched dual-trace operation cannot be accomplished. To adjust this balance, place the following controls in the positions indicated:

AC-GND-DC	(both CH 1 and CH 2)	GND
MODE		CH 2
V POSITION	(both CH 1 and CH 2)	Center of range

(After DC BAL control has been correctly adjusted.)

With these controls set as indicated, adjust R139, COMMON MODE CURRENT' (see Fig. 6–2) so that 0V are obtained at the Test point (emitter of TR112) shown in Fig. 6–2.

Next, switch the MODE selector to CH2, and adjust R123 Aa, CH 1 VOLT ADJ, (see Fig. 6–2) to obtain 0V at the emitter of TR112.

STABILITY

This control is used to calibrate the operating points of the gate multivibrator or the sweep generator. If the circuit is not properly calibrated, it may not function properly for the triggered sweep and free-run sweep operations.

Set the following controls

SOURCE	INT NORM
COUPLING	AC
VOLTS/DIV	5 mV
Input signal	CAL OUT 0.02V

Perform the calibration with the STABILITY control (R415, refer to Fig. 6–5) so that the sweep will stop when the (PUSH AUTO) LEVEL switch is pulled, and go into a free-run sweep status when the switch is depressed. Make sure that the sweep is triggered when the LEVEL control is returned to the mechanical midpoint and stops upon turning the control to the extreme counterclockwise or clockwise position in the triggered mode, but goes into a free-run status in the auto mode. Since the variable range of R415 is very wide, set this control to a safe position for proper calibration.

0 ADJ

Unless the DC level of the common trigger signal for CH 1 and CH 2 is set to zero volts, center of the LEVEL may change when the SOURCE switch to DC.

Move the vertical position of the trace up to center of the CRT screen and perform the calibration with R188 0 ADJ (Refer to Fig. 6–1) so that potential at the test point of Fig. 6–1 (TRIG OUT) will become zero volts.

TRIG SENS

TRIG SENS is calibrated after completion of the calibration of the 0 ADJ control.

Calibration is performed in the following manner.

Input signal	50 Hz sine wave
COUPLING	DC
V POSITION	Approximate mechanical midpoint

Now, provide a triggered sweep. Adjust the TRIG SENS control (R322, Refer to Fig. 6–2) so that the sweep will start at the same point when the SLOPE control is switched.

LEVEL CENT

This adjustment is performed after TRIG SENS has been accurately calibrated. Adjust the trigger level as follows:

Input signal	Sine wave, 50 Hz – 1 kHz
COUPLING	AC
LEVEL	Center of range

The sweep should be triggered at this time. Place the SLOPE switch in the + or – position, and adjust R315, LEVEL CENT (see Fig. 6–2) so that the sweep is symmetrical in both the + and – positions.

SWEEP TIME (TIME/DIV)

Calibration of the sweep time is accomplished in the following manner: First, set the control as follows;

MODE (top of the instrument) NORMAL
TIME/DIV 1 mSEC

Next, apply an input signal having accurate 1 millisecond intervals to the INPUT connector and adjust R521, SWP CAL, (see Fig. 6–5) to make the signal conform to the graticule divisions.

SWP LENGTH

Perform calibration of this control after completion of the calibration of the sweep time.

It is convenient for observation to calibrate the trace length to 10.5 to 12 divisions when the TIME/DIV switch is in the 1 mSEC position. The SWP LENGTH control (R451) is shown in Fig. 6–5.

MAG GAIN

Calibration of this control should be done after the sweep time has been calibrated. The display is magnified at each position as follows:

Table 6–3

MAG Range	TIME/DIV	Input Signal	Display size on the CRT
X10	1 msec	2 KHz	5 division
X20	. 2 msec	10 KHz	10 division
X50	. 1 msec	100 KHz	5 division

EXT HORIZ GAIN

Perform calibration of this control after the SWP CAL and X10 GAIN controls have been calibrated.

First, set the SOURCE to EXT and couple the CAL OUT 0.2V to TRIG OR HORIZ IN connector. Set the TIME/DIV to EXT HORIZ. Calibrate the EXT GAIN ADJ (R327, Refer to Fig. 6–2) for a horizontal amplitude of 4 divisions. Next, set the SOURCE switch to EXT ÷ 10 and apply a calibrating signal from the CAL OUT 2V terminal. Make sure that the horizontal amplitude is also 4 divisions.

If the horizontal amplitude does not meet the specification (±3%), error in element resistance value of the EXT ÷ 10 attenuator is considered too high.

MAG CENT

This control is adjusted so the magnified display positions in the center of graticule. First, set the MAG switch to the 20 position, and adjust the H POSITION control so the sweep starts from the center of graticule. Then, switch the MAG switch to the 1 position, and adjust the R252 MAG CENT (See Fig. 6–5) so that the sweep start point, shifted when the switch was changed, will come to the center of graticule.

CALIBRATING VOLTAGES

The calibrating voltages can be automatically calibrated when the +10V of the low-voltage power supply is exactly calibrated.

Fig. 6–5

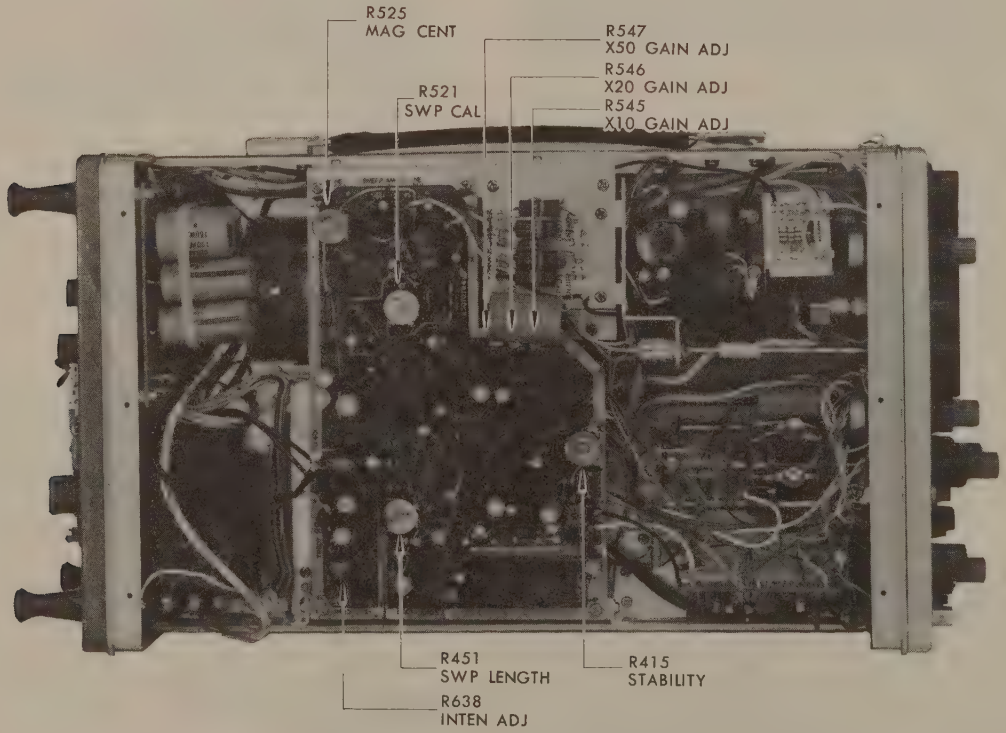
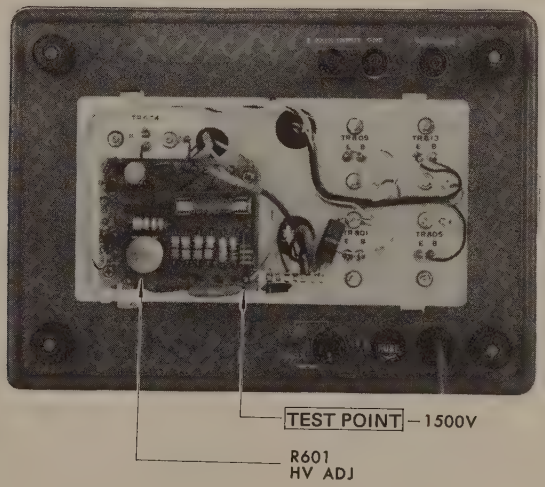

R525
MAG CENT
R547
X50 GAIN ADJ
R546
X20 GAIN ADJ
R521
SWP CAL
R545
X10 GAIN ADJ
R451
SWP LENGTH
R415
STABILITY
R638
INTEN ADJ

Fig. 6–6



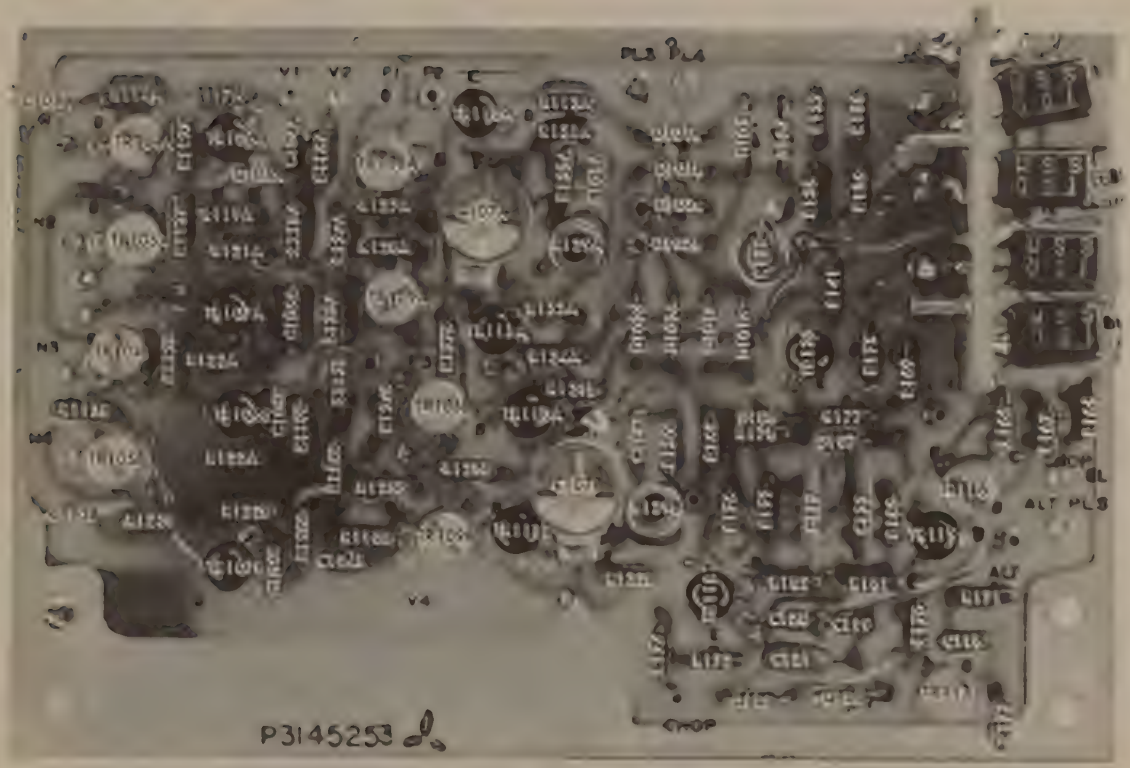
Abbreviations used in this manual are as follows:

◆For units:

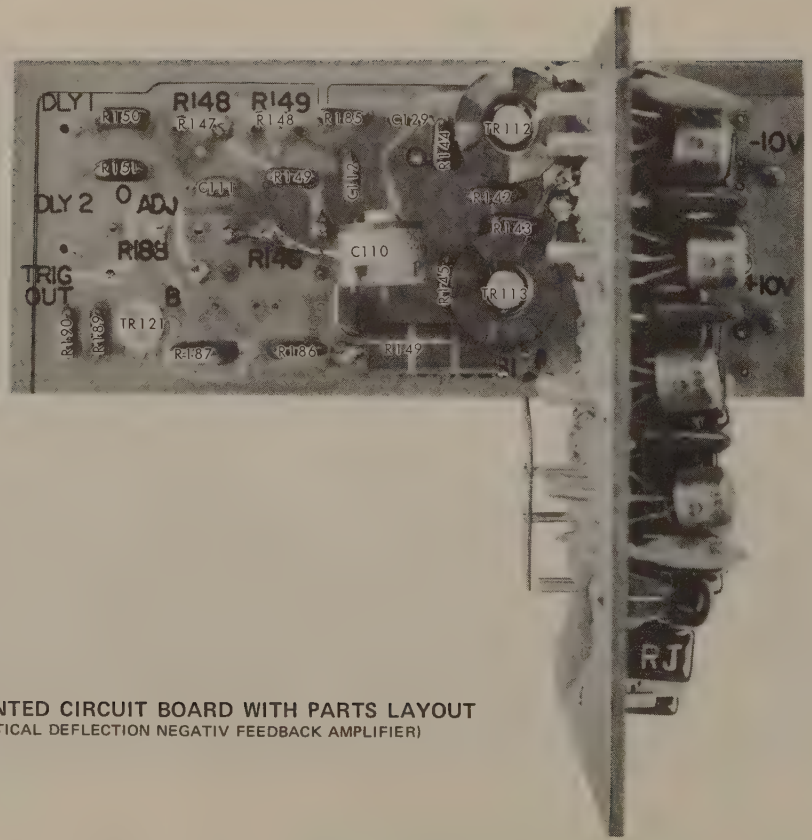
A	ampere
mA	milliampere
μA	microampere
nA	nanoampere (10^{-9} A)
dB	decibel
div (DIV)	division
g	gram
kg	kilogram
Hz	hertz
kHz	kilohertz
MHz	megahertz
GHz	gigahertz
m	meter
cm	centimeter
mm	millimeter
sec (SEC)	second
msec	millisecond
μsec	microsecond
nsec	nanosecond (10^{-9}sec)
psec	picosecond (10^{-12}sec)
F	farad
μF	microfarad
pF	picofarad
V	volt
mV	millivolt
μV	microvolt
VA	voltampere
W	watt
mW	milliwatt
Ω	ohm
MΩ	megohm
kΩ	kilohm
rms	root mean square
p-p	peak to peak

◆Others:

AC	alternate current
ADJ	adjust
ALTER	alternate
ASTIG	astigmatism
AUTO (Auto)	automatic
BAL	balance
CAL	calibrated
CAL OUT	calibrator output
CENT	center
CH 1	channel 1
CH 2	channel 2
CHOP	chopped
DC	direct current
EXT	external
GND	ground (earth)
HF REF	high frequency reject
HORIZ	horizontal
ILLUM	illumination
INT	internal
INTEN	intensity
LF REJ	low frequency reject
MAG	magnifier
NORM	normal
SENS	sensitivity
SWP	sweep
TRIG	trigger
UNCAL	uncalibrated
VERT	vertical



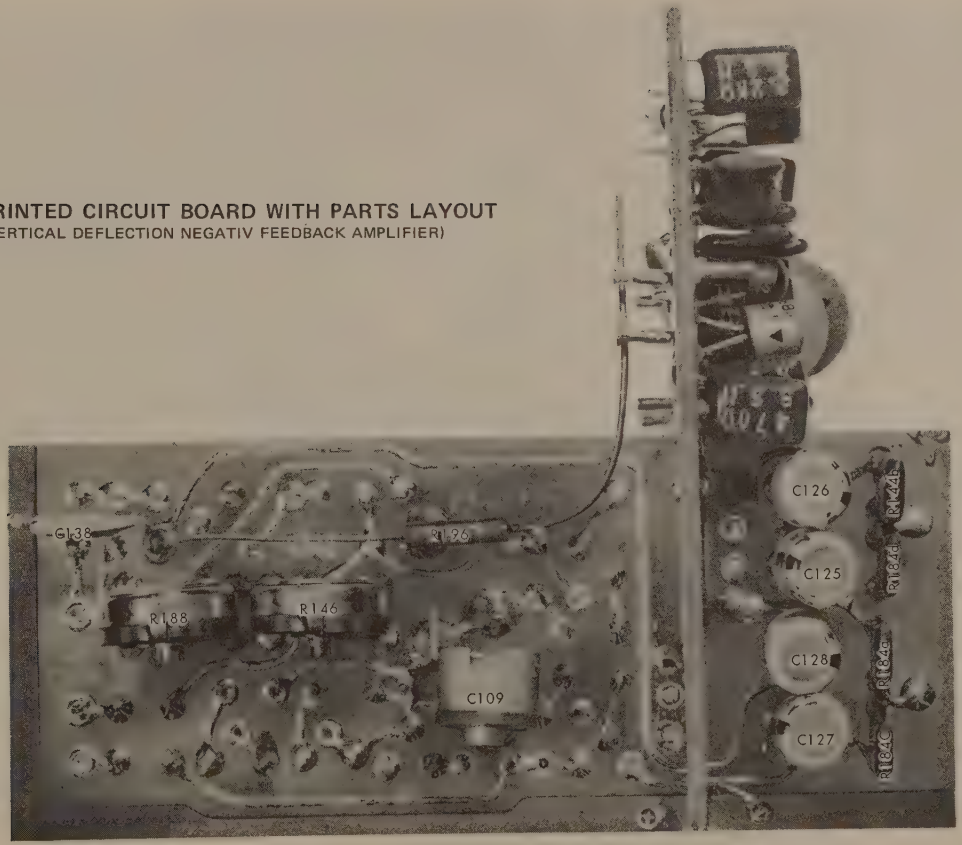
PRINTED CIRCUIT BOARD WITH PARTS LAYOUT
(VERTICAL DEFLECTION, CH 1, CH 2 PRE AMPLIFIER, DIODE GATE CIRCUIT, SWITCHING MULTI CIRCUIT)

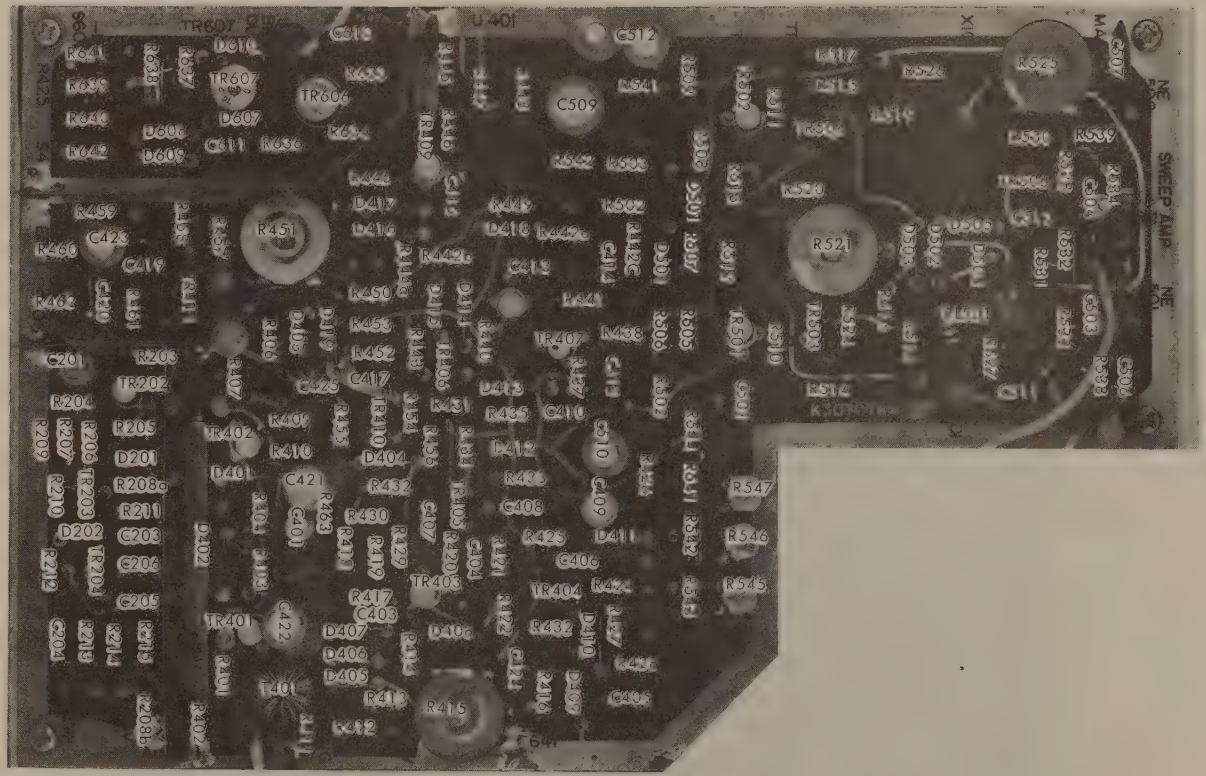


PRINTED CIRCUIT BOARD WITH PARTS LAYOUT
(VERTICAL DEFLECTION NEGATIV FEEDBACK AMPLIFIER)

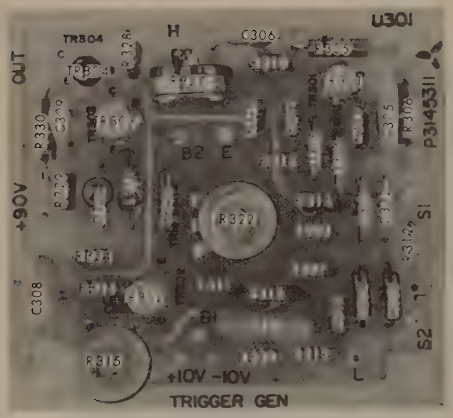
PRINTED CIRCUIT BOARD WITH PARTS LAYOUT

(VERTICAL DEFLECTION NEGATIV FEEDBACK AMPLIFIER)

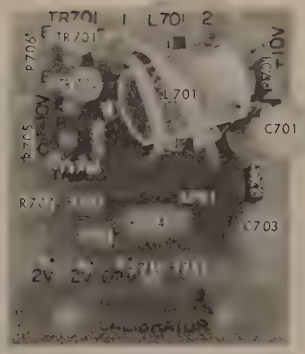




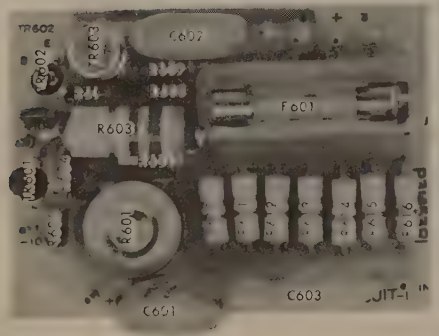
PRINTED CIRCUIT BOARD WITH PARTS LAYOUT
(TRIGGER AMPLIFIER · SANTOOTH GENERATOR · HORIZONTAL AMPLIFIER · Z-AXIS AMPLIFIER)



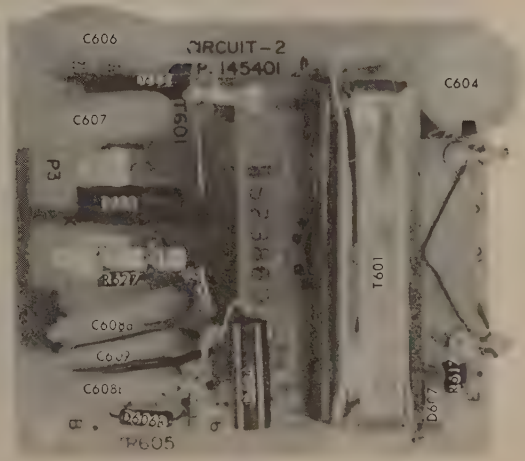
TRIGGER CIRCUIT



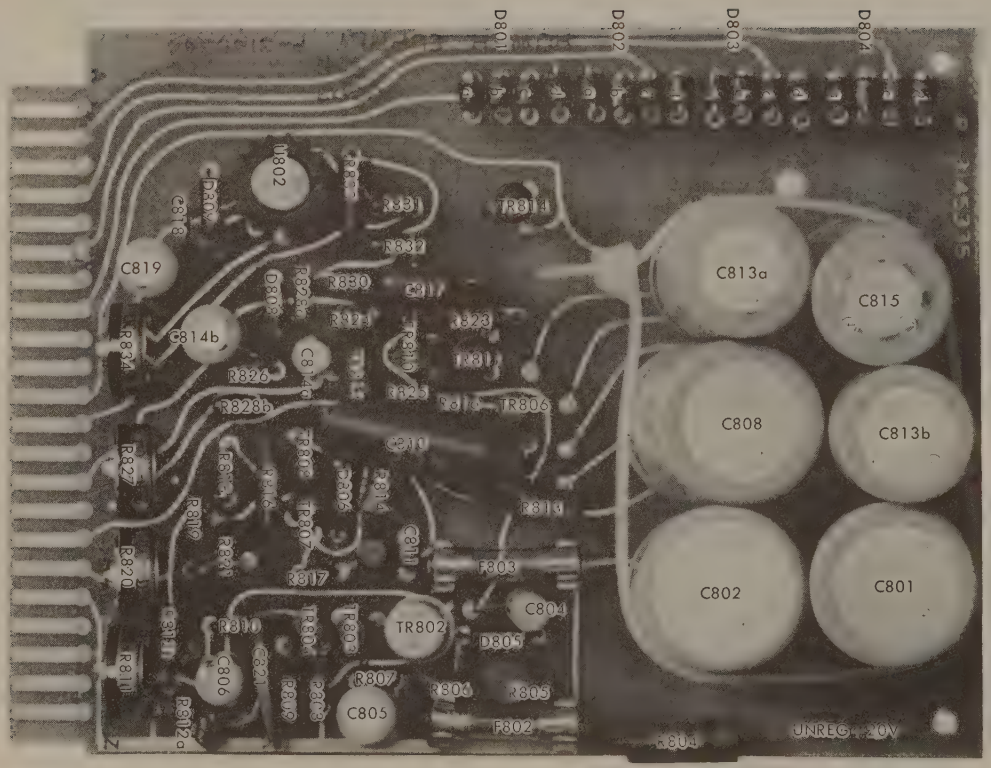
CARIBRATOR CIRCUIT



HIGH VOLTAGE CIRCUIT (CONTROL)



HIGH VOLTAGE CIRCUIT (OSC)



PRINTED CIRCUIT BOARD WITH PARTS LAYOUT
(POWER SUPPLY CIRCUIT)

PARTS LIST

PARTS ORDERING INFORMATION

Replacement parts will be available from Iwatsu factory or through Iwatsu representative. Make sure to check the detailed specified value and tolerance in this list before any replacement.

When you place order for replacement, it is requested to furnish us scope model, its serial No.; and relative circuit No. and parts code No.

ABBREVIATIONS:

Cer	Ceramic
EPT	Electrolytic paper or metal tubuler
EPC	Electrolytic paper or metal cased
Poly	Polystyrene
WW	Wire-wound
Var	Variable
Prec	Precision

MANUFACTURERS:

NEC	Nippon Electric Co., Ltd.
Toshiba	Tokyo Shibaura Electric Co., Ltd.
Hitachi	Hitachi Ltd.
KH	Komatsu-Hoffman Electronics Co., Ltd.
IR	International Rectifier Corporation, Ltd.
Sanken	Sanken Electric Co., Ltd.
F.H.	Fairchild Semiconductor Products, Inc.
RCA	RCA Corporation

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
CAPACITORS		
C405, 412, 122, 123	20000pF $^{+80}_{-20}$% 50V Cer.	74060-2680
C203, 205, 206, 306, 408, 424, 425, 426, 501, 502, 513, 611, 612, 613, 818, 124A, 124B, 138, 140, 103A, 103B, 136	10000pF $^{+80}_{-20}$% 50V Cer.	74060-0650
C301, 305, 506, 507, 610, 821, 101A, 101B, 116, 117, 137	10000pF $^{+80}_{-20}$% 500V Cer.	74060-0730
C309, 419	1500pF $^{+80}_{-20}$% 50V Cer.	74050-3010
C403, 417, 418 420, 105A, 105B, 106A, 106B	1000pF $^{+80}_{-20}$% 50V Cer.	74060-2670
C415	470pF $^{+80}_{-20}$% 50V Cer.	74050-2730
C406	390pF $^{+80}_{-20}$% 50V Cer.	74050-5860
C416F	220pF $^{+80}_{-20}$% 500V Cer.	74050-2030

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C013A, 013B, 302b	220pF $^{+80}_{-20}$% 500V Cer.	74050-5820
C404, 310	220pF $^{+80}_{-20}$% 50V Cer.	74050-4010
C407, 413	150pF $^{+80}_{-20}$% 50V Cer.	74050-1730
C303	120pF $^{+80}_{-20}$% 500V Cer.	74050-1950
C302a	100pF $^{+80}_{-20}$% 500V Cer.	74050-1930
C410, 202	100pF $^{+80}_{-20}$% 50V Cer.	74050-1710
C004A, 004N	80pF $^{+80}_{-20}$% 500V Cer.	74050-3650
C010A, 010B	50pF $^{+80}_{-20}$% 500V Cer.	74050-1910
C139b	30pF $^{+80}_{-20}$% 500V Cer.	74050-3870
C414	30pF $^{+80}_{-20}$% 50V Cer.	74050-5450
C601	0.22μF $^{+80}_{-20}$ 50V Polyester.	74130-2370
C204, 307, 308, 416C, 602, 817	0.1μF $^{+80}_{-20}$% 50V Polyester.	74130-2470
C001A, 001B	0.1μF $^{+80}_{-20}$% 630V (DC) Polyester.	74130-2620

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C702	0.047μF $^{+80}_{-20}$% 50V Polyester.	74130-2770
C416D	10000pF $^{+80}_{-20}$% 50V Polyester.	74130-2460
C121	4700pF $^{+80}_{-20}$% 50V Polyester	74130-2640
C416E	1000pF $^{+80}_{-20}$% 50V Polyester	74130-2450
C411A	1μF $^{+0}_{-2}$% 50V Polyester	74130-2270
C411B, 703	0.1μF $^{+0}_{-2}$% 50V Polyester	74130-2190
C411C	0.01μF $^{+0}_{-2}$% 50V Polyester	74130-1760
C410	0.001μF $^{+0}_{-2}$% 300V Polyester	74130-2630
C019A, 019B	2700pF ±5% 50V Mica.	74090-4240
C016A, 016B	470pF ±5% 50V Mica.	74090-4250
C118	100pF ±10% 50V Mica.	74090-4310
C411F, 411H, 104B	82pF ±10% 50V Mica.	74090-4230
C112	56pF ±10% 50V Mica.	74090-4620
C104A, 119, 120	47pF ±10% 50V Mica.	74090-4850
C108A, 108B	22pF ±10% 50V Mica.	74090-4860
C113, 114	18pF ±10% 50V Mica.	74090-4630
C111	7pF ±10% 50V Mica.	74090-4610
C129	5pF ±10% 50V Mica.	74090-4640

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C813a, 813b, 813c, 815, 816	470μF $^{+100}_{-10}$% 25V EPT	74120-0260
C409	47μF $^{+100}_{-10}$% 6,3V EPT	74100-8260
C701	47μF $^{+100}_{-10}$% 16V EPT	74100-9980
C604	47μF $^{+100}_{-10}$% 25V EPT	74100-9930
C801a, 801b, 802 808, 809	47μF $^{+100}_{-10}$% 160V EPT	74100-8820
C505, 803	33μF $^{+100}_{-10}$% 350V EPT	74120-0370
C130, 131, 132, 421, 422, 423, 510, 512, 814b, 819	33μF $^{+100}_{-10}$% 16V EPT	74100-9950
C807, 820	10μF $^{+100}_{-10}$% 160V EPT	74100-3820
C125–128, 201 416A	10μF $^{+100}_{-10}$% 16V EPT	74100-8200
C402, 806	10μF $^{+100}_{-10}$% 25V EPT	74100-3030
C509, 812	4.7μF $^{+100}_{-10}$% 160V EPT	74100-3870
C133–185, 804 814a	3.3μF $^{+150}_{-10}$% 35V EPT	74100-8320
C401, 416B	1μF $^{+150}_{-10}$% 50V EPT	74100-2890

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C102AB	3.3μF 3V EPC	74100-8810
C110	5.5 – 25pF 350V Cer Var.	74110-0670
C107AB, 411EG	5.5 – 25pF 350V Cer Var.	74110-0110
C017AB, 014AB 304	3.5 – 20pF 350V Cer Var.	74110-0100
C007AB, 009AB 011AB, 012AB 015AB	5 – 12pF 350V Cer Var.	74110-0080
C109	2.3 – 8pF 350V Cer Var.	74110-0680
C006AB, 008AB 18AB	2.3 – 8pF 350V Cer Var.	74110-0500
C002AB, 003AB	3 – 7pF 250V Cer Var.	74110-0660
C503, 504	0.5 – 1.5pF Poly Var.	74110-0290

RESISTORS

R199BC	1/2W 10 ±2%	74241-0010
R804	1W 10 ±2%	74242-0010
R323	1/4W 20 ±2%	74244-0680
R803	1/2W 47 ±2%	74241-0120
R301	1/4W 47 ±2%	74244-0020
R152, 153, 196	1/4W 100 ±2%	74244-0030
R837	2W 100 ±2%	74243-0170
R140	1W 180 ±2%	74242-0040
R433	1/4W 300 ±2%	74244-0650
R133B, 134B	1/4W 330 ±2%	74244-0470
R535	1/2W 330 ±2%	74241-0320
R432	1/4W 680 ±2%	74244-0530
R158AB, 159AB	2W 750 ±2%	74243-0320
R154, 155	1/4W 1k ±2%	74244-0050
R520	1/2W 1k ±2%	74241-0440
R516, 517	1/4W 1.3k ±2%	74244-0830
R510, 511	1/4W 2.4k ±2%	74244-0550
R509	1/4W 2.7k ±2%	74244-0600
R507	1/4W 3k ±2%	74244-0320
R199A	1/2W 3.6k ±2%	74241-0550
R422C	1/2W 4.7k ±2%	74241-0580
R508	1/4W 5.1k ±2%	74244-0770
R805	1W 6.2k ±2%	74242-0470
R634	1W 6.8k ±2%	74242-0480
R624E	1/2W 10k ±2%	74241-0660
R536AB, R537AB	2W 10k ±2%	74243-0570
R448, 512, 513	1W 12k ±2%	74242-0540
R514, 515	1/4W 15k ±2%	74244-0100
R466, 605	1/2W 15k ±2%	74241-0690
R405	1/2W 18k ±2%	74241-0710
R518, 519	1W 18k ±2%	74242-0580
R540	1/4W 20k ±2%	74244-0440
R447	1W 20k ±2%	74242-0590
R644	1/2W 22k ±2%	74241-0730
R436K, 465, 533 534, 816	1/2W 24k ±2%	74241-0740
R330	1/2W 27k ±2%	74241-0750
R632	1/4W 30k ±2%	74244-0620
R406	1/2W 33k ±2%	74241-0770
R618, 814	1/2W 39k ±2%	74241-0790

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R629	1/4W 39k ±2%	74244-0430
R162, 163, 630	1/4W 51k ±2%	74244-0140
R302B	1/2W 100k ±2%	74241-0890
R303	1/2W 110k ±2%	74241-0900
R149	1/2W 120k ±2%	74241-0910
R621	1/2W 220k ±2%	74241-0970
R835, 836	1/2W 330k ±2%	74241-1010
R609	1/4W 430k ±2%	74244-0840
R160, 161, 306	1/2W 470k ±2%	74241-1050
R616	1W 470k ±2%	74242-0870
R624A	1/2W 620k ±2%	74241-1080
R304	1/2W 910k ±2%	74241-1120
R305, 102AB	1/2W 1M ±2%	74241-1130
R184A,B,C,D, 214, 215, 463, 464, 633, 644, 701	1/4W 10 ±5%	74230-0070
R441, 442A	1/4W 22 ±5%	74230-0870
R329	1/4W 33 ±5%	74230-0280
R103AB, 104AB 111AB, 123AB 190 – 193, 213 216, 309, 320 437, 501, 639	1/4W 47 ±5%	74230-0100
R205	1/4W 62 ±5%	74230-1240
R116AB	1/4W 68 ±5%	74230-1050
R324	1/4W 75 ±5%	74230-0880
R150, 151	1/4W 91 ±5%	74230-1230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R114AB, 310, 435 438, 439, 442B 607, 635, 830	1/4W 100 ±5%	74230-0130
R123B, 202, 417 815	1/4W 150 ±5%	74230-0510
R130AB, 831, 839	1/4W 180 ±5%	74230-0860
R119AB, 120AB, 156, 411	1/4W 220 ±5%	74230-0480
R141, 401, 452 460	1/4W 270 ±5%	74230-0910
R206	1/4W 300 ±5%	74230-1160
R133A, 134A	1/4W 330 ±5%	74230-0470
R170	1/4W 360 ±5%	74230-1110
R319, 325, 424	1/4W 390 ±5%	74230-0550
R142, 143, 168 169	1/4W 430 ±5%	74230-1300
R121AB, 122AB, 165, 420, 425, 426, 529, 530, 702, 705	1/4W 470 ±5%	74230-0160
R110AB, 111, 194 195, 407, 423 429	1/4W 510 ±5%	74230-0450
R210, 419, 456 838	1/4W 620 ±5%	74230-1040
R131AB, 132AB, 173, 174	1/4W 680 ±5%	74230-0150
R454	1/4W 820 ±5%	74230-0230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R414, 828A	1/4W 910 ±5%	74230-1260
R166, 211, 212	1/4W 1k ±5%	74230-0030
307, 308, 410		
427, 531, 532		
637, 640, 641		
643		
R316, 317, 321	1/4W 1.2k ±5%	74230-0500
R828B	1/4W 1.3k ±5%	74230-1330
R117AB, 118A,	1/4W 1.5k ±5%	74230-0110
177, 178, 826		
R428, 642	1/4W 1.6k ±5%	74230-1320
R135, 136, 144	1/4W 1.8k ±5%	74230-0810
145, 430		
R183AB, 326, 416	1/4W 2k ±5%	74230-0410
R172, 179, 180	1/4W 2.2k ±5%	74230-0270
403, 446, 450		
703		
R137, 138	1/4W 2.4k ±5%	74230-0220
R175, 176, 810	1/4W 2.7k ±5%	74230-0420
R207, 413,434	1/4W 3k ±5%	74230-0530
449		
R418, 821	1/4W 3.3k ±5%	74230-0350
R208A	1/4W 3.6k ±5%	74230-1080
R197, 201, 328	1/4W 3.9k ±5%	74230-0090
412, 431		
R112AB, 113AB,	1/4W 4.3k ±5%	74230-1310
189, 443		
R127AB, 128AB,	1/4W 4.7k ±5%	74230-0290

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
181, 182, 204		
R453, 806	1/4W 5.1k ±5%	74230-1020
R198, 636	1/4W 5.6k ±5%	74230-0520
R312, 318, 506	1/4W 6.2k ±5%	74230-0890
R401, 421, 706	1/4W 6.8k ±5%	74230-0330
R157	1/4W 9.1k ±5%	74230-1090
R187, 185, 203	1/4W 10k ±5%	74230-0120
404, 440, 461		
524, 526, 604		
824		
R124AB, 125AB	1/4W 12k ±5%	74230-0440
106AB, 107AB		
R409, 445, 455	1/4W 15k ±5%	74230-0140
466, 502		
R186, 209	1/4W 18k ±5%	74230-0460
R109AB, 311, 314	1/4W 20k ±5%	74230-0310
444B		
R809	1/4W 24k ±5%	74230-0800
R817-819	1/4W 30k ±5%	74230-0920
R642, 612B	1/4W 36k ±5%	74230-0900
R444A	1/4W 39k ±5%	74230-0780
R167, 527, 525	1/4W 47k ±5%	74230-0170
645, 704, 832		
R503	1/4W 51k ±5%	74230-1010
R105AB	1/4W 56k ±5%	74230-0560
R825	1/4W 62k ±5%	74230-0930
R812	1/4W 75k ±5%	74230-0590
R807	1/4W 82k ±5%	74230-0340

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R505	1/4W 91k ±5%	74230-1000
R302A, 458, 608	1/4W 100k ±5%	74230-0260
617, 808		
R603	1/4W 1.5M ±5%	74230-1460
R622, 624A,B,C	1/4W Prec 1.5M ±1%	74281-0010
R457	1/4W Prec 2.2M ±1%	74281-0030
R615	1/4W Prec 2.7M ±1%	74281-0040
R610 – 614	1/4W Prec 3.3M ±1%	74281-0060
R459	1/2W Prec 4.7M ±1%	74282-0180
R602	1/2W Prec 5.1M ±1%	74282-0190
R710, 711	1/4W Prec 8 ±1%	74212-1890
R709	1/4W Prec 36 ±1%	74212-1720
R708	1/4W Prec 360 ±1%	74212-1710
R707	1/4W Prec 1.59k ±1%	74212-1880
R813	2W 100 ±5%	74310-1970
R823, 833	0.5	Iwatsu
R013AB, 014AB	1/4W Prec 10 ±1%	74253-0650
R001AB, 002AB	1/4W Prec 47 ±1%	74253-0750
R154B, 164A,	1/4W Prec 100k ±1%	74253-0850
436L		
R436H	1/2W Prec 150k ±1%	74226-2070
R436I	1/2W Prec 225k ±1%	74226-1180
R436E	1/2W Prec 2.25M ±1%	74226-1140
R436D	1/2W Prec 3.75M ±1%	74226-1130
R436C	1/2W Prec 7.5M ±1%	74226-1120
R436B	1/2W Prec 10M ±1%	74226-0940
R436A	1/2W Prec 12.5M ±1%	74226-2060
R005AB, 436FG	1/2W Prec 750k ±1%	74226-1160

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R007AB	1/2W Prec 900k ±1%	74226-1800
R009AB	1/2W Prec 990k ±1%	74226-1400
R011AB	1/2W Prec 999k ±1%	74226-1990
R004B, 101AB	1/2W Prec 1M ±1%	74226-0160
R006AB	1/2W Prec 333k ±1%	74226-1330
R003AB	1/2W Prec 500k ±1%	74226-1340
R012AB	1/4W Prec 1k ±1%	74226-0010
R010AB	1/4W Prec 10.1k ±1%	74226-0030
R008	1/4W Prec 111k ±1%	74226-0060
R318 (S401)	Resistor, Var with switches 50k	74325-2480
R504A, 504B		
(S501)		
R620, 623	Var 2M	74323-0400
R322	Var 200	74349-0510
R129AB	Var 200	74349-1250
R827, 834	Var 500	74349-0260
R451	Var 1k	74322-1210
R521	Var 2k	74322-1300
R820	Var 2k	74349-0270
R327	Var 5k	74349-0320
R415	Var 5k	74322-1220
R628	Var 5k	74349-0810
R811	Var 10k	74349-0370
R108AB	Var 10k	74349-1240
R525	Var 20k	74322-1280
R638, R188	Var 50k	74349-0220
R436J	Var 50k	74322-1810
R631, 626	Var 100k	74349-0800

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R146	Var 100k	74349-0350
R601	Var 100k	74322-1500
R123Aa	Var 200k	74349-0540
R115AB (S102AB)	Var 300k	74349-0250
R139	Var 1k	74349-0710
R208B	Var 10k	74349-1070
R147	Var 20k	74390-0960
R126AB	Var (10 + 10)k	74322-1800

DIODES

D109AB, 303, 304	NEC RD-4A	74040-0760
D202, 409, 809	NEC RD-6A	74040-0790
D806	NEC RD-9A	74040-0840
D805	NEC RD-11A	74040-1800
D606b	NEC RD-13A	74040-0890
D403	NEC RD-19A	74040-0940
D605	NEC RD-29A	74040-2060
D606a	KH HW-91A	74040-3240
D807	NEC IS-551	74040-0640
D419	NEC IS-1198	74040-2380
D101a–101d	NEC IS-1588	74040-3150
102a–102d		
103–108, 201		
301, 302, 305		
306, 401, 402		
405–407, 410		
412–414, 418		
501–505		
507–610, 808		
D415–417	Hitachi IN34A	74040-0700
D602–604	IR LA-60	74040-2130
D601	Sanken HF SD-1	74040-3140
D803a–803d	IR 10D-2	74040-2110
804a–804d		
D801a–801d	IR 10D10	74040-2750
802a–801d		

INDUCTORS

L101, 102	Peaking Coil	74400-2723
	Core, Ferrite	74560-0890
	Coil Bobbin	74520-0540
L301	Coil for Tunnel	74400-2880
	Core Dust	74560-0110
L401	Core Ferrite	74560-0090
L501	Fery Inductor	74470-1260
L601	Rotation Coil	74400-328

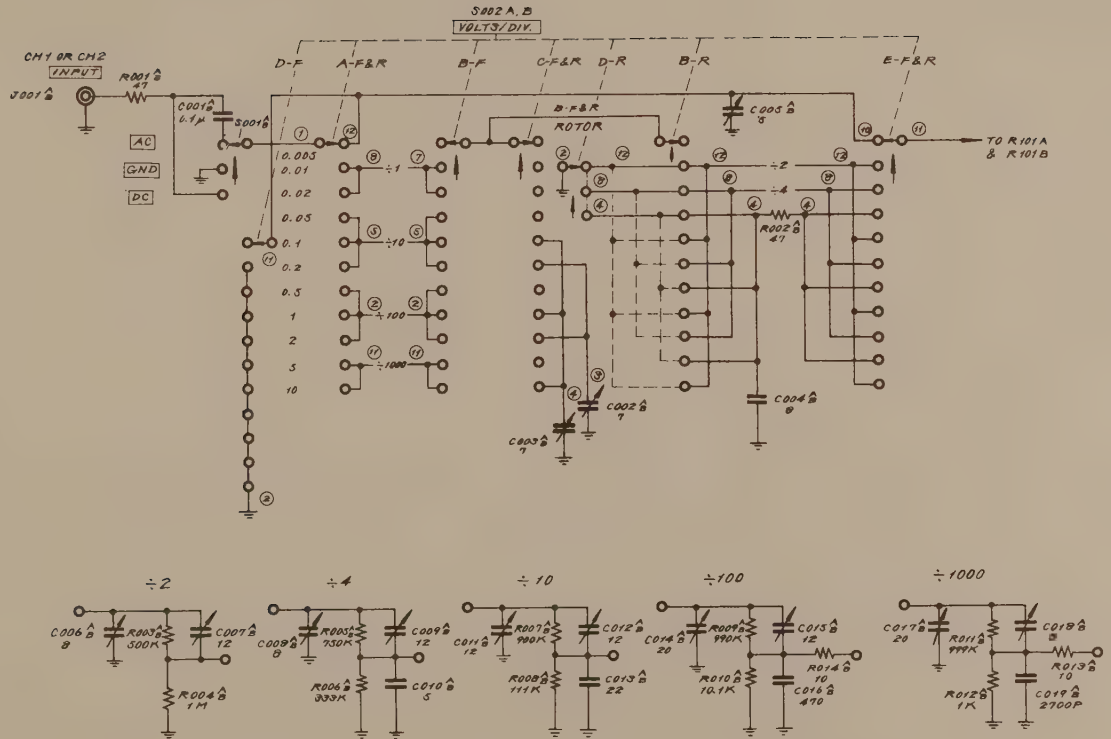
TRANSISTORS

TR805	2SC685 Hitachi NPN	74030-3570
TR112, 113	2SC689 Hitachi NPN	74030-3620
TR801	2SC779 F.H NPN	74030-3650
TR604	2SD91 Sanken NPN	74030-4560
TR809, 813	2SD91 Sanken NPN	74030-4450

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
TR114, 115, 507	2N3119 RCA NPN	74030-1830
508		
TR106AB, 107AB	2N4121 F.H PNP	74030-2990
118–120, 203		
204, 304, 404		
405, 406, 503–506		
602, 703		
TR110AB, 111AB	2N4275 F.H NPN	74030-3160
SWITCH		
S802		74440-0150
S801 (PL801)	Push with lamp	74440-1300
S101, 403	Slide	74440-0190
S303	Lever	74440-0520
S601 (NE401)	Push with neon lamp	74440-0560
S001AB	Lever	74440-0770
S404	Push	74440-1180
S301	Lever	74440-1230
S302	Lever	74440-1240
S102	Rotary	74431-5280
S002AB	Rotary	74431-5443
S402	Rotary	74431-5455
TRANSFORMER		
T401	Transformer for pulse	74473-0190
T601	Transformer for H.V. power	74472-1012
T701	Transformer for Caribrator	74472-0650
T801	Transformer for L.V. power	74471-1892
TERMINAL		
TB101	Ground terminal 8mmϕ	74510-0140
TB401, 402, 403	Terminal 9.5mmϕ	74510-0090
JACK CONNECTOR		
J801	Connector	74500-2980
J001AB, 301	Connector	74500-2530
NEON LAMP		
NE101, 102, 103AB, 402, 501, 502	Neon lamp NE-2	74020-1100
RELAY		
RL501	Micro relay	74450-0640
FUSE		
F601	Fuse 0.5A	74540-0050
F802, 803	Fuse 0.25A	74540-0370
F801	Fuse 1A	74540-0420

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
F801	Fuse holder	74480-0950
ILLUMINATION LAMP		
PL802	6.3V 150mA	74490-0130
CATHODE RAY TUBE		
V103	Hitachi H8503A-B31	74010-0950

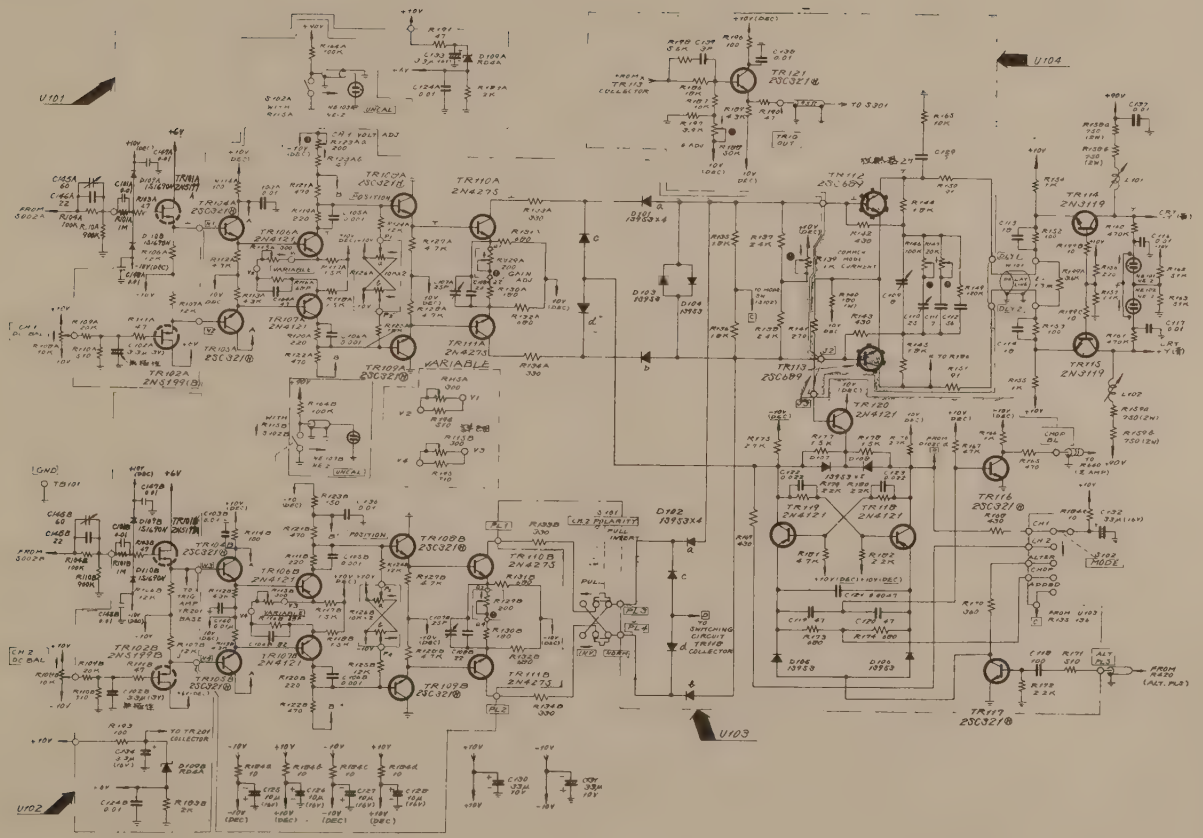
CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
IC		
U802	NEC PC-4	74030-4330
CABLE		
W101	CD	74160-0090



注. CH.1, CH.2 と共通図番
CH.1 --- □□A
CH.2 --- □□B

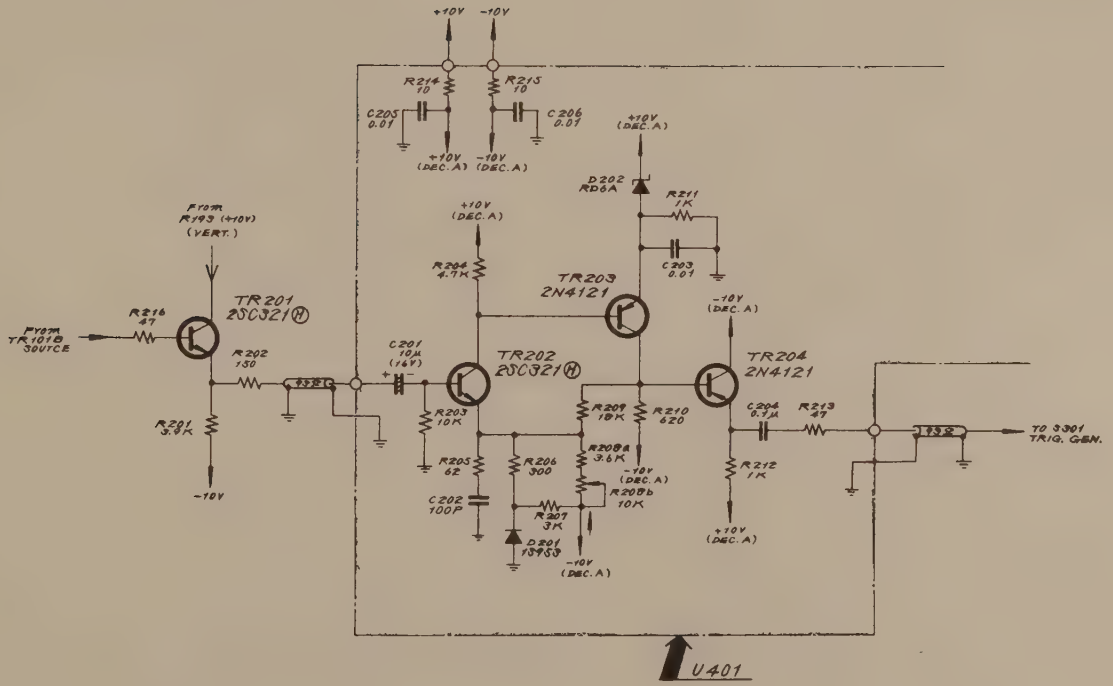
CH 1 & CH 2 VOLTS/DIV.

P－603690



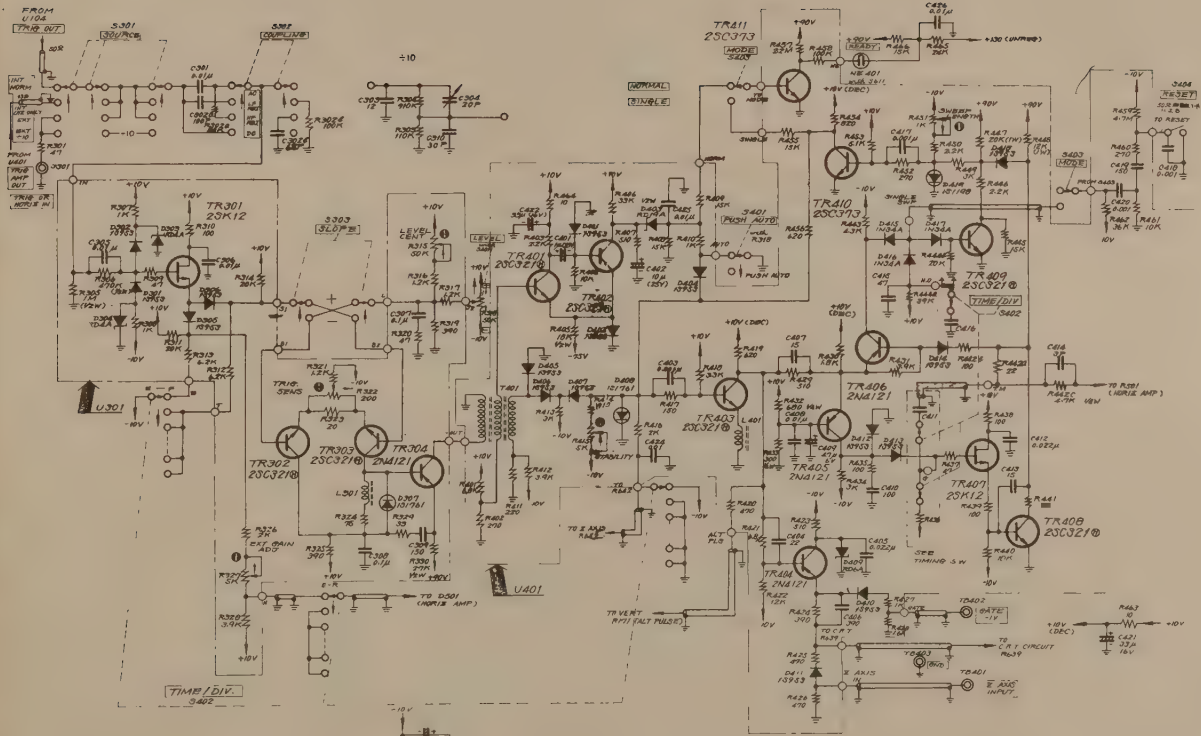
VERTICAL AMP.

K−605030−4



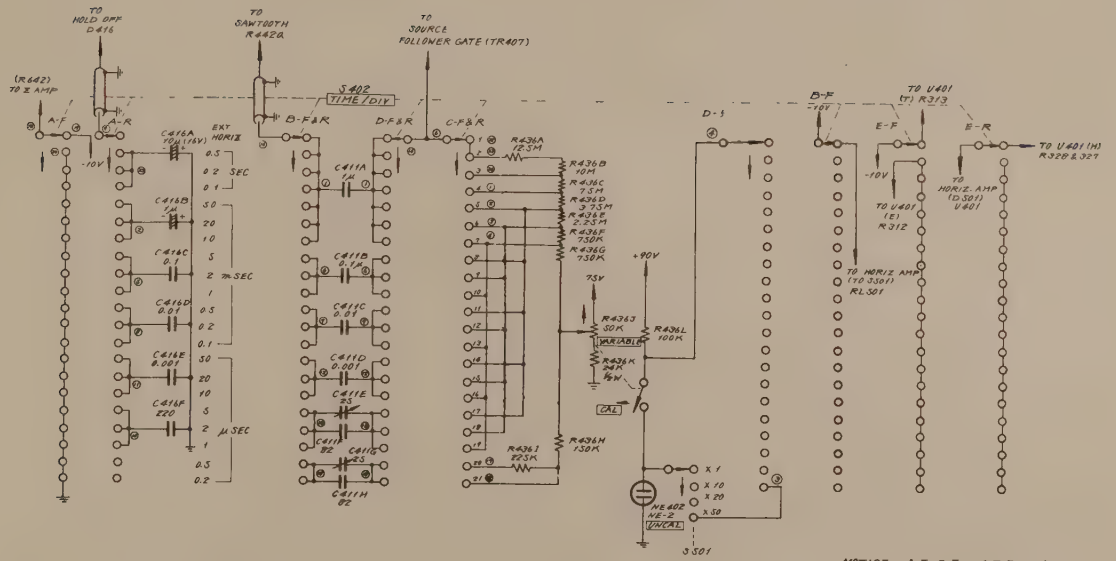
TRIG. SIG. AMP.

P−603691−2



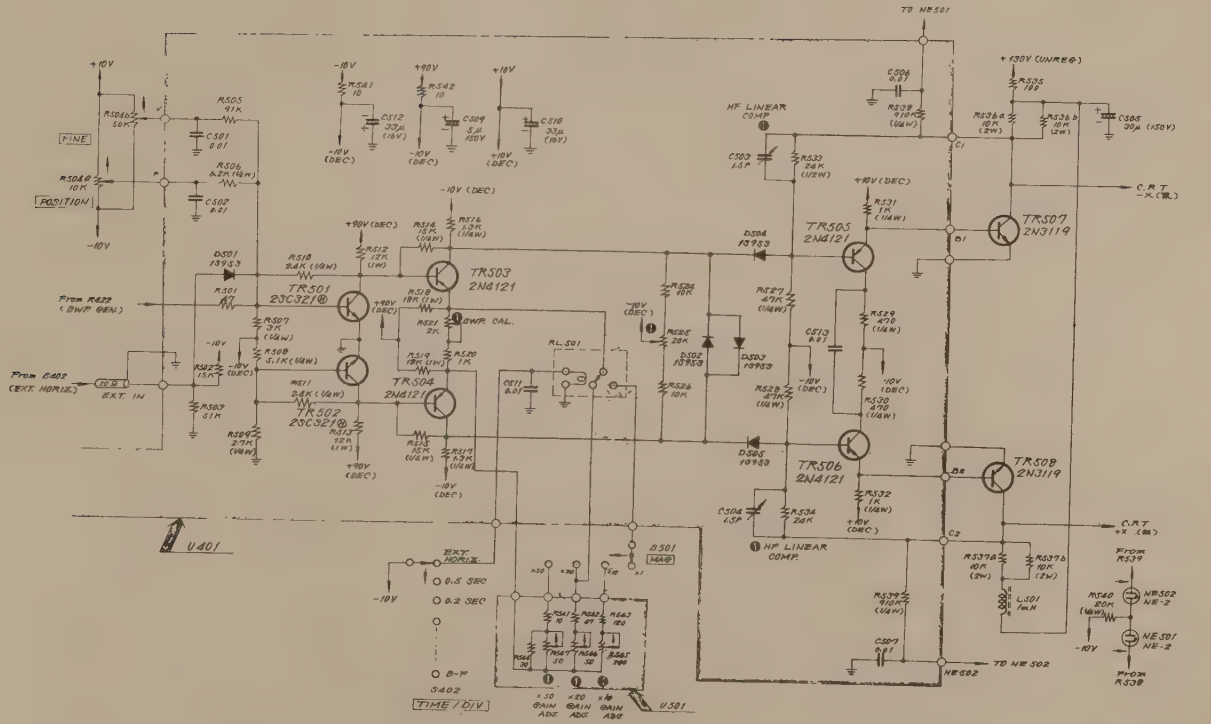
TRIGGER & SWEEP GEN.

K-605031-4



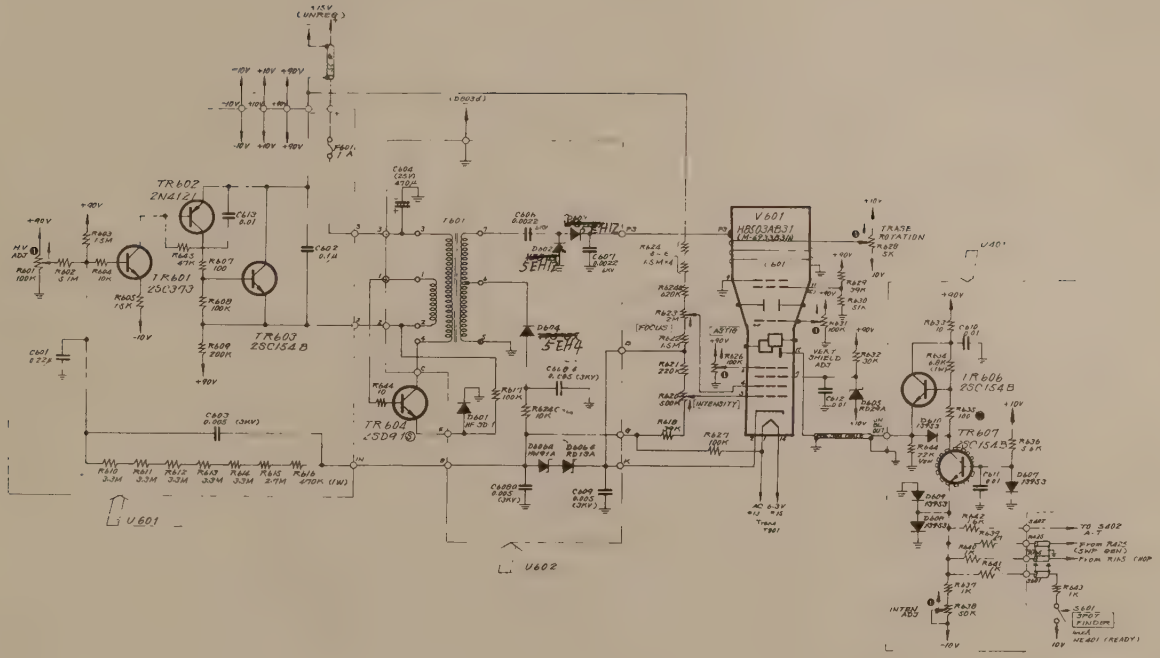
TIME/DIV. SWITCHES

P−610045



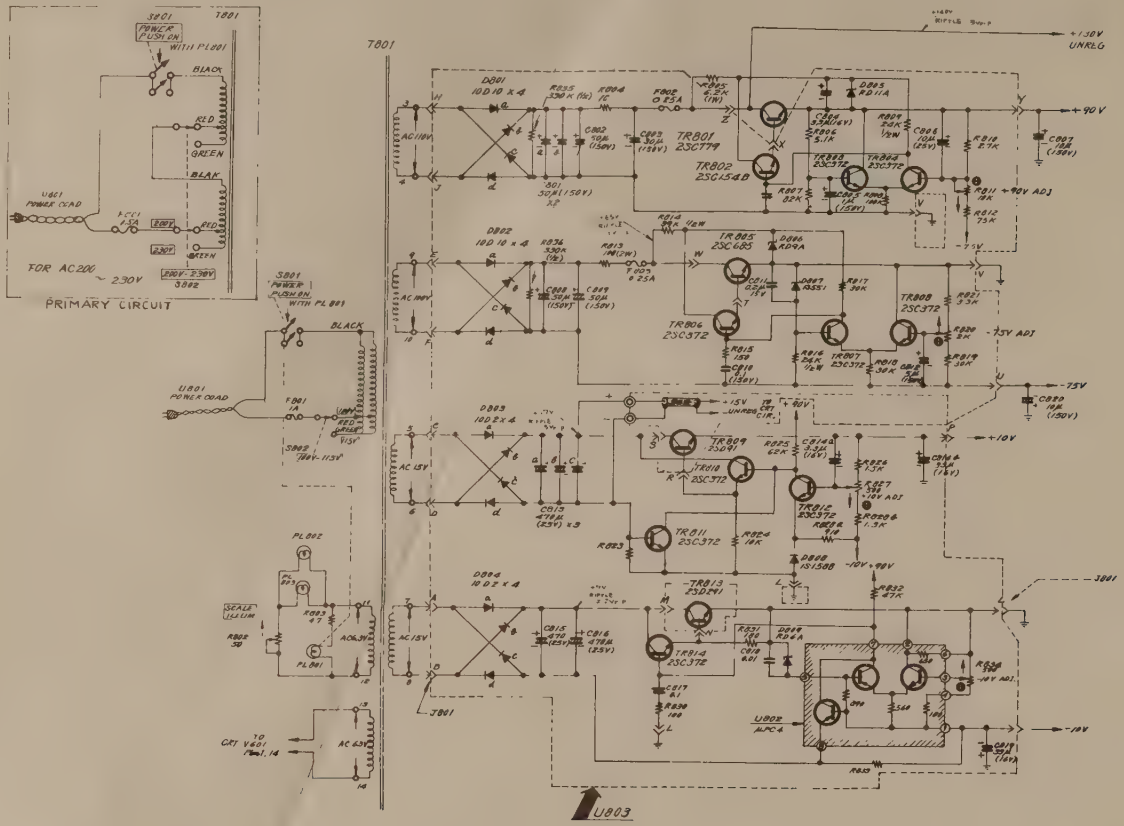
HORIZONTAL AMP.

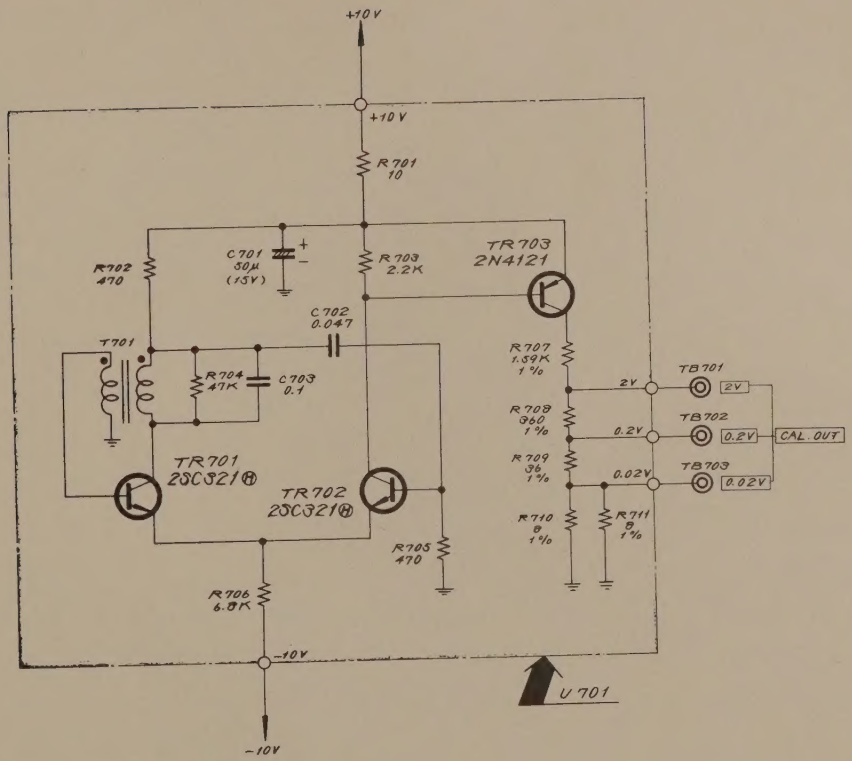
K-604880-3



C.R.T. CIRCUIT

K−605033−6


POWER SUPPLY
K-605034



CALIBRATOR

P-603693-2

IWATSU ELECTRIC CO., LTD.